# Update on Percutaneous AV Fistula Creation

Drs. Jeffrey E. Hull and Dheeraj K. Rajan discuss technical concepts and ongoing research in this emerging option for hemodialysis access.

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**How would you briefly summarize the specific unmet clinical need that your device development and its associated research aim to meet?**

**Dr. Rajan:** Dialysis patients need consistent, effective, reproducible, permanent vascular access. Although surgical arteriovenous (AV) fistulas have the best outcomes, they have shortcomings. Surgical AV fistulas fail up to 60% of the time, require multiple interventions to maintain functionality, and often take several months to achieve usability. In addition, patients often wait to have AV fistulas placed surgically; in North America, the wait is > 3 months. All of these factors lead to patients' extended exposure to central venous catheters, which nobody wants for their patients due to the increased risk for infection and mortality risk.

The everlinQ system (TVA Medical, Inc.) creates AV fistulas that are usable for dialysis and appear to resist closure with fewer interventions. We are further evaluating if fistulas created using our minimally invasive technique result in a more reproducible access with improved clinical outcomes. This may translate into better quality of life for patients and may potentially reduce hemodialysis access maintenance costs.

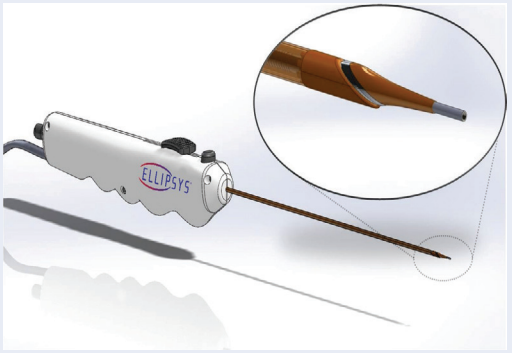
**Dr. Hull:** In the United States and around the world, there is a shortage of dedicated access surgeons to create AV fistulas. The Ellipsys system (Avenu Medical) could increase the number and types of physicians capable of creating reliable fistulas to include endovascular surgeons, interventional radiologists, and interventional nephrologists. In addition to this, important goals are to improve patient care by creating and maturing fistulas quickly to reduce the time from request for fistula to usable access for dialysis, thereby reducing morbidity associated with temporary catheter access.

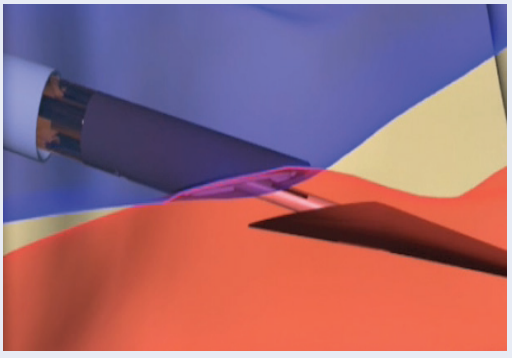
**Dr. Rajan, at CiDA 2014, during your presentation on everlinQ, you mentioned that you were skeptical when you were first presented with this concept. Why was that, and was there a single experience that changed your perspective?**

**Dr. Rajan:** As an endovascular specialist performing dialysis interventions, the ability to create a dialysis fistula percutaneously has always been somewhat of an ultimate goal or desire. Despite all the advances in endovascular interventions within the past 20 years, no one intervention has been successful in creating a percutaneous access solution. Given that there have been no changes in the status quo, it is natural to be apprehensive about any idea. The single experience that changed my perspective was when we successfully created a fistula percutaneously in a cadaveric arm and then did it again three more times in a single day.

## TECHNIQUES AT A GLANCE

**Ellipsys Vascular Access System**
By Jeffrey E. Hull, MD



Patients are started on aspirin and clopidogrel 48 to 72 hours prior to the procedure. The procedure is done with local regional anesthesia. I often perform a supraclavicular brachial plexus block, but this is not required. The antecubital fossa is sterilely prepped and draped. Retrograde access to the cubital vein is obtained with ultrasound guidance, which is also used to perform the remaining steps in the procedure. The access needle is directed toward the perforating vein. The wire is advanced through the needle into the perforating vein. The access needle is advanced over the wire through the perforating vein to the proximal radial artery. The proximal radial artery lies medial to the perforating vein and is entered as it would be in any ultrasound-guided arterial access procedure. The wire is advanced into the radial artery. The needle is withdrawn, and a 6-F sheath is placed over the wire into the artery. The Ellipsys catheter is positioned through the sheath, and the artery and vein wall are engaged. The catheter is closed and activated, and the fistula is created using low-power direct current energy. The sheath is removed, and hemostasis is achieved with gentle pressure.

### Dr. Hull, please tell us how the concept for the Ellipsys vascular access catheter originated.

**Dr. Hull:** A friend and I engaged in a thought experiment. The question was: "What is something in your field of medicine that could improve patient care by becoming minimally invasive and has not changed in 30 years?" My immediate response was the AV fistula for dialysis. Not only had the basic technique of creating an AV fistula not changed considerably since 1966 when initially described by Brescia and Cimino, but the sutured anastomosis also had not significantly changed since initially described by Carrel in 1902. My friend and mentor, Dr. Chris Young, introduced me to Dr. Steve Parker and the team that developed the system for total arthroscopic rotator cuff repair and the system for vacuum-assisted percutaneous breast biopsy. After considerable due diligence, including mapping out the appropriate anatomy and designing a single catheter system that would make an anastomosis without leaving an implant behind, we formed Avenu Medical (formerly named Caymus Medical).

### Avenu Medical currently has an investigational device exemption (IDE) study underway in the United States. What can you tell us about its design and enrollment progress to date?

**Dr. Hull:** The IDE study is a prospective, single-arm, phase 3, safety and efficacy study. The successful cannulation of percutaneous fistulas is being compared against the surgical literature. Two of five sites are up and running, and recruitment is going well.

### Dr. Rajan, TVA Medical gained CE Mark approval for the everlinQ device in September 2014. What is its current market availability, and what plans are there for United States studies? How is the progress on the Canadian study?

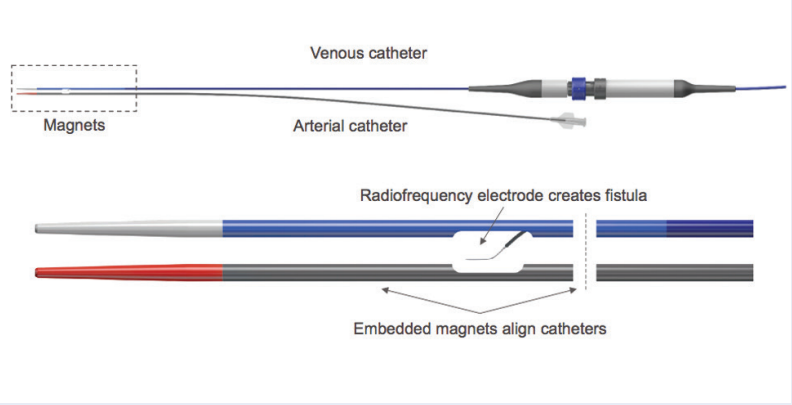
**Dr. Rajan:** Before marketing everlinQ in Europe, TVA Medical plans to gather additional clinical evidence and physician experience. This includes a postmarket study in Europe starting later in 2015. The NEAT (Novel Endovascular Access Trial) study in Canada, Australia, and New Zealand, is progressing well with strong recruitment. We anticipate that enrollment will be completed in 2015 with follow-up into 2016. TVA Medical is currently in discussions with the US Food and Drug Administration, and the everlinQ system is currently not available in the United States.

### What were the key take-home points and lessons learned in your recently published study?

**Dr. Rajan:** The FLEX study showed that endovascular AV fistula creation is possible with high technical success rates, low failure rates, and low intervention

## TECHNIQUES AT A GLANCE

**everlinQ System**
By Dheeraj K. Rajan, MD




First, access is gained to the brachial vein using a micropuncture set and 0.018-inch guidewire under ultrasound guidance. The guidewire is advanced to the ulnar vein under fluoroscopy, and a 7-F dilator and sheath are inserted. Next, with ultrasound, arterial access is gained in the brachial artery using a micropuncture set and 0.018-inch guidewire, the guidewire is advanced to the ulnar artery, and a 6-F dilator and sheath are inserted. Under fluoroscopy, one everlinQ magnetic catheter is inserted into the artery, and the other magnetic catheter is inserted into the vein. The magnets are poled in each of the catheters to pull the artery and vein together as well as to align a spring-loaded radiofrequency electrode in the venous catheter and a ceramic backstop in the arterial catheter. The radiofrequency electrode is released from the venous catheter and energized for 2 seconds, creating a channel between the vein and the artery. The electrode is retracted, and both devices are removed. Before removing the venous sheath, one of the brachial veins is embolized with a coil to force blood to the superficial veins. Finally, the arterial sheath is removed and the arterial access closed per standard technique. The AV fistula should be assessed at 4 weeks for usability, and cannulation options are similar to that of a brachiocephalic AV fistula and/or a Gracz AV fistula. Needles may be split between vein segments to optimize dialysis delivery and reduce admixture.

rates, and these results compare favorably to surgical AV fistula creation. In our study, 96% of the patients were successfully dialyzed using the FLEX EndoAVF (TVA Medical, Inc.) at an average of 2 months after the procedure.

### Dr. Hull, how would you summarize the results you have seen to date?

**Dr. Hull:** The IDE trial data are not available. Outside the United States, an intent-to-treat analysis shows 70% of patients achieved dialysis. At 6 months, > 90% of patients with fistulas created were successfully dialyzed, alive, and available for follow-up.

### Which patients are not ideal candidates for percutaneous fistula placement?

**Dr. Rajan:** Patients who do not meet surgical criteria for fistula creation are also not candidates for percutaneous creation. For example, patients with vessels < 2 mm or with central vein stenosis are not ideal candidates for a percutaneous fistula.

**Dr. Hull:** Patients who are good candidates for a distal wrist fistula should have a radiocephalic fistula to maximize the use of vein. Patients with poor-quality perforating veins but good cephalic or basilic veins should have a surgical fistula.

### Understanding that the full potential must still be evaluated in ongoing studies, what do you see as the most likely role of percutaneous AV fistula creation? In other words, where will this option fit into most practices?

**Dr. Hull:** The Ellipsys access system fits well into our current practices as follows. Imagine that you're taking care of the patient approaching dialysis or with a nonfunctioning catheter or a failing graft. The patient is vein mapped at the office, and willing candidates for percutaneous fistulas undergo the procedure in the next few days without the need for additional referrals or consultations. Patients who are not suitable for percutaneous fistulas are scheduled for surgery. Because fistula creation using the Ellipsys system is performed in a typical procedure room with ultrasound guidance, it fits in well with the other access procedures done at the office-based vascular center. The physician creating the fistula follows the patient through maturation and gets him or her started on dialysis using the fistula.

**Dr. Rajan:** I believe percutaneous AV fistula creation will transform the vascular access space by providing more patients with a working fistula, both for predialysis patients and dialysis patients who've had previous fistula failures. Patients are provided with an additional anatomic option by creating endovascular AV fistulas in the deep

system, without consuming valuable veins that can be used for additional future surgical or endovascular access procedures. In addition, patients with limited vein options or those who are more clinically challenging, potentially requiring a two-stage surgical procedure, may benefit from percutaneous AV fistula creation, thus eliminating a surgical procedure. Additionally, a reproducible minimally invasive procedure will facilitate AV fistula creation in an outpatient setting and will increase the types of physician specialties that can create fistulas—this will hopefully reduce the long wait times, such as those we see in North America. However, I do not see this replacing surgery completely; there will remain a substantial need for surgical access creation for more complicated accesses/patients.

### How would you describe the learning curve or training required to effectively use the technique you are researching?

**Dr. Rajan:** The learning curve for creating an AV fistula using the everlinQ system is short. Physicians with interventional skills and endovascular experience should be proficient with the procedure after about three cases. For those with less endovascular experience, training with a few additional cases may be needed. Overall, anyone with the skill set required for peripheral arterial interventions should be able to perform the procedure.

**Dr. Hull:** Using the Ellipsys vascular access system is very similar to placing a peripherally inserted central catheter line and obtaining arterial access with ultrasound. The procedure requires the same skill set as these two procedures. Most physicians involved in vascular access have these skills and will learn to use the Ellipsys catheter quickly. A critical part of the procedure is to understand the anatomy of the cubital fossa, including the proximal radial artery, perforating vein, and the cubital veins draining into the basilic and cephalic vein. We have found the best way to train physicians on this anatomy is to have them pick up an ultrasound probe and study this anatomy in themselves and their patients.

New or different techniques and approaches may be required to use and maintain the percutaneous fistula. A main difference between the surgically created fistula and the percutaneous fistula is that the latter has multiple potential outflow veins, including the cephalic vein, the basilic vein, and retrograde flow in forearm veins. In percutaneous fistulas, both the median cephalic and the median basilic vein (cubital veins) often mature.

In a surgical fistula, nearly the entire circuit of the fistula and inflow artery can be accessed from the fistula itself. This is in part because a surgical fistula is created by attaching a single vein to an artery and ligating all the branches. The best approach to work on the percutaneous fistula is from the radial artery at the wrist. This location allows angioplasty of the anastomosis or inflow as well as deep embolization of the brachial vein when needed (in approximately 30% of fistulas created with the Ellipsys catheter). We have employed banding of the median basilic vein to drive blood flow into the cephalic vein without sacrificing the basilic vein, which can be used if the cephalic vein does not mature. We have performed percutaneous valvulotomy to

#### IN THE LITERATURE

**Dr. Hull's Recommendations**

**Percutaneous Proximal Radial Artery Arteriovenous Fistula Creation for Hemodialysis Using the Ellipsys Vascular Access System**
Hull JE, Velez JH, Martinez JP.
*J Vasc Interv Radiol*. 2014;25(3 suppl):S20.

**Mapping of the Snuffbox and Cubital Vessels for Percutaneous Arterial Venous Fistula (pAVF) in Dialysis Patients**
Hull JE, Kinsey EN, Bishop WL.
*J Vasc Access*. 2013;14:245–251.

**Percutaneous Valvulotomy as an Alternative to Transposition of a Brachiocephalic Fistula**
Hull JE, Makhoul RG, Snyder JF.
*J Vasc Interv Radiol*. 2014;25:144–147.

**Computational Fluid Dynamic Evaluation of the Side-to-Side Anastomosis for Arteriovenous Fistula**
Hull JE, Balakin BV, Kellerman BM, Wrolstad DK.
*J Vasc Surg*. 2013;58:187–193 e1.

**Percutaneous Creation of an Arteriovenous Fistula for Hemodialysis Access**
Rajan DK, Ebner A, Desai SB, et al.
*J Vasc Interv Radiol*. 2015;26:484–490.

**Dr. Rajan's Recommendations**

**Safety and Efficacy of Percutaneous Autogenous Arteriovenous Fistula Creation with the TVA FLEX System: Expanded Results Beyond the Pilot Study**
Rajan DK, Ebner AA, Rios JM, et al.
*J Vasc Interv Radiol*. 2014;25(3 suppl):S19.

**Percutaneous Creation of an Arteriovenous Fistula for Hemodialysis Access**
Rajan DK, Ebner A, Desai SB, et al.
*J Vasc Interv Radiol*. 2015;26:484–490.

create retrograde flow down the forearm veins for dialysis access. Vascular access specialists have to become familiar with the differences between percutaneous and surgical fistulas. These techniques are in the wheelhouse of most physicians doing vascular access work.

### What are some of the potential roadblocks to adopting these technologies, should they reach market approval with reasonable reimbursements?

**Dr. Hull:** We would be thrilled to have these elements. Market approval and reimbursement in the outpatient center are the biggest obstacles to this technology. I would say that the relationship between the percutaneous fistula and the surgical fistula is similar to the relationship between that of abdominal aortic endograft and an open surgical repair. The two procedures require different approaches to planning, execution, and follow-up to effectively obtain a good clinical result. Vascular access specialists will have to embrace these changes for the percutaneous fistula to be successful.

**Dr. Rajan:** This is a paradigm shift, similar to endovascular aneurysm repair and transcatheter aortic valve replacement, so it is important that the introduction of this technology on a wide scale be performed methodically. As with prior fundamental shifts in practice, some will react negatively and advocate against change. The key will be to continue developing the appropriate clinical evidence, refining patient selection for the procedure, and ensuring physicians are properly trained and equipped to perform the procedure.

### Although it is likely early to ask this, do you believe that there are any other possible applications for these devices?

**Dr. Rajan:** There are other potential applications of this technology. However, our principal focus is on dialysis access creation because this is a substantial unmet clinical need.

**Dr. Hull:** Other dialysis fistula locations, such as the snuffbox, wrist, and cubital fossa, would likely follow successful use at the proximal radial artery. The ability to create a reliable anastomosis using a catheter would have broad application in vascular surgery and even microsurgery. Laparoscopic surgery and peripheral bypass surgery would be fertile ground for use of this technology. Computational dynamic studies have shown that the side-to-side anastomosis similar to those created by both the Avenu and TVA Medical's catheters have favorable flow and wall shear stress characteristics to limit intimal hyperplasia. ■