

# The SIR 2016 Panel on Endovascular Arteriovenous Fistula Creation

Highlights from an expert panel held at the Society of Interventional Radiology's 2016 annual scientific sessions, including summaries of existing technologies, experiences to date, and key questions posed by the audience.

## PANEL



**Moderator**  
**Dheeraj K. Rajan, MD, FSIR**  
University of Toronto  
Toronto, Canada  
*Disclosures: Paid consultant and shareholder, TVA Medical.*



**Ravi Sidhu, MD**  
The University of British Columbia  
Vancouver, British Columbia  
*Disclosures: Participant in TVA Medical's NEAT.*



**Jeffrey E. Hull, MD**  
Richmond Vascular Center  
Richmond, Virginia  
*Disclosures: Founder and consultant, Avenu Medical.*



**Kenneth R. Thomson, MD, FSIR**  
Alfred Hospital  
Melbourne, Australia  
*Disclosures: Research support for participation in TVA Medical's NEAT.*



**Jason Clement, MD**  
The University of British Columbia  
Vancouver, British Columbia  
*Disclosures: Paid consultant, TVA Medical.*

Early adopters and clinical investigators of percutaneous arteriovenous fistula creation (pAVF) for hemodialysis access gathered in a dedicated panel session at the 2016 Society of Interventional Radiology Scientific Meeting in Vancouver, British Columbia. Moderated by Dheeraj K. Rajan, MD, from the University of Toronto, the panel included investiga-

tors experienced with the two pAVF platforms currently being evaluated (TVA Medical's everlinQ endoAVF System and the Ellipsys system by Avenu Medical): Jeffrey Hull, MD, who is the founder and a stockholder in Avenu Medical; Ravi Sidhu, MD, from the University of British Columbia; Kenneth R. Thomson, MD, FSIR, from Alfred Hospital in Australia; and Jason Clement, MD, from the

University of British Columbia, who served as an expert panelist but did not separately present materials.

In introducing the panel, Dr. Rajan focused on its diversity in terms of specialty, nationality, and familiarity with each device, and in his opening remarks, asked that the audience consider the session more of an open forum aimed at discussion rather than didactics.

Dr. Sidhu opened the discussion by sharing his perspective as the lone vascular surgeon among a panel of interventional radiologists, noting that he surgically creates AVFs in addition to creating the fistula endovascularly in the NEAT trial. He began with a brief overview of the rationale supporting AVF creation, reviewing data from several trials in the medical and nephrology literature that showed survival benefit for AVFs versus other options such as central venous catheters, grafts, and peritoneal dialysis, and the goals set forth for fistula use in the National Kidney Foundation Disease Outcome Quality Initiative (KDOQI).

### VASCULAR ACCESS AND FISTULA CREATION: A SYSTEMATIC APPROACH

In discussing ideal dialysis access creation and after care, Dr. Sidhu underscored the importance of a systematic, multidisciplinary, patient-centered approach. This begins with the primary care physician recognizing chronic kidney disease, referral to a nephrologist, and timely preparation for renal replacement therapy. Of particular importance to the vascular community is the timely referral for vascular access creation, as it is unlikely that fistula prevalence targets will be met if patients in need of urgent dialysis are referred. Patients should undergo proper preoperative assessment for all possible access options and ultimately the timely creation of the access best suited to each individual's needs for maturation and readiness for hemodialysis, he said.

When selecting access creation sites, Dr. Sidhu's facility takes many factors into consideration, including clinical observations, patient preferences, and ultrasound findings, which they use liberally in their evaluations. Their center's preferences include nondominant arms over dominant arms, lower arms over upper arms, arms over legs, and veins over grafts, with hybrid grafts representing a possible final stage.

### FISTULA INCIDENCE, PREVALENCE, AND OUTCOMES

In British Columbia, Canada, Dr. Sidhu's practice area, the fistula incidence rate in patients with prior chronic kidney disease status was 41% according to population-based figures he cited that spanned the 6-month period ending September 30, 2015. Fifty-seven percent had

catheters placed, and 2% had grafts. Although it was noted that this rate is not ideal for fistula incidence, it represents real-world use across all centers, physicians, and patients, and it exceeds what was observed in previous periods.

Dr. Sidhu also shared outcomes from his practice, a high-volume, university-based surgical unit. In their previous 450 surgical AVF creations in either the forearm (n = 138) or upper arm (n = 312), they saw a total primary failure rate of 26%. The group feels this failure rate is consistent with rates in the literature. However, it was noted that failures can be disconcerting for patients. Depending on the manner and location of AVF creation, they have seen 1-year primary patency rates hovering in the 43% to 55% range, with the majority of patients receiving multiple interventions. In summary, there are relatively high primary failure rates for surgical AVF (similar to rates he has observed in the literature), and consequently, high rates of reintervention, indicating room for improvement.

Beyond statistics such as a mean maturation time of 4 to 9 months, Dr. Sidhu emphasized the patient experience as another area with room for improvement. The desire to undergo a second or even third surgical fistula creation is understandably low on the part of the patient, as are expectations that the next fistula will succeed when previous attempts did not. Additional areas for potential improvement include consistency of surgical techniques and reducing the costs of reinterventions and complications.

### PERCUTANEOUS FISTULA CREATION OPTIONS

Next, Drs. Hull and Thomson presented the rationale of pAVF and some collected experiences to date with the Ellipsys and everlinQ systems, respectively.

Dr. Hull, founder of Avenu Medical, began with a brief timeline related to AVF creation, bookended by Alexis Carrel's first description of the sutured anastomosis in 1902 and the introduction of percutaneous fistula creation in 2012 (TVA Medical) and 2013 (Avenu Medical). Other points of interest on the timeline included the first AVF described by Brescia-Cimino in 1966, and, particularly relevant to this talk, Gracz's brachial to perforating vein fistula in 1977, the same year Toledo-Pereyra described the proximal radial artery to perforating vein fistula.

The pAVF procedure requires a skill set comparable to placing a peripherally inserted central catheter and ultrasound-guided arterial access, said Dr. Hull. He emphasized the importance of having a strong knowledge of antecubital fossa and perforating vein anatomy, which he described as the gateway between the deep and superficial systems.

### The Ellipsys System

After reminding the audience that the Ellipsys is not approved by the US Food and Drug Administration (FDA), Dr. Hull described his goals in designing the device: to have single-catheter system that works over the wire, requires only venous access, is usable with ultrasound guidance, uses low-power thermal energy, and leaves no implant behind.

The Ellipsys device creates an automated side-by-side anastomosis between vessels that are in direct contact, a concept Dr. Hull described as “tissue welding” akin to laparoscopic procedures that use welding to cut and seal a vessel, rather than tying a suture. Instead of needing to block the blood flow from a 5-mm artery, the flow is directed into a low-resistance circuit. Dr. Hull then briefly described and illustrated animal, histological, and human images showing similarity between surgical AVF and pAVF. Potential advantages of side-to-side anastomosis creation were also discussed, including more uniform wall shear stress<sup>1</sup> and less intimal hyperplasia<sup>2</sup>; one study showed a reduction in surgical AVF failure from 40% to 17% with side-to-side anastomosis.<sup>3</sup>

In a previous *Endovascular Today* discussion, Dr. Hull described the procedure as follows:

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.

In his presentation at SIR, Dr. Hull went into further detail on his use of a brachial plexus block when creating a pAVF, relaying that this method provides sufficient analgesia and good vasodilatation, as well as preventing thrombosis in surgical fistulas.<sup>4</sup> Additionally, he said that vein mapping is performed before all fistula creations,

identifying the perforating vein and proximal radial artery, ensuring that the vessels are > 2 mm in diameter and there is no signal dropout due to calcification. To mature a fistula for dialysis needle access, he aims to have brachial artery flow > 800 mL/min and a palpable target vein with at least 500 mL/min. To improve target vein access, the deep flow can be embolized, the basilic vein can be ligated, and on rare occasions, a valvulotomy can be used to gain retrograde flow in the median vein.

### The everlinQ endoAVF System

Prof. Ken Thomson shared experiences using the everlinQ system, which has CE Mark and Health Canada approval. The device is currently being evaluated by the FDA and not available for use in the United States.

In *Endovascular Today's* previous coverage of pAVF, Dr. Rajan described the everlinQ procedure as follows:

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 in the dialysis clinic are similar to that of a brachiocephalic AV fistula and/or a Gracz AV fistula. Dialysis needles may be split between two vein segments or into a single vein segment to optimize dialysis delivery.

Prof. Thomson emphasized the need for a 2-mm vein for this procedure, as well as healthy outflow veins; in order to determine candidacy, one of his first steps is to obtain a venogram to ensure the great veins are not damaged.

Among the advantages of this procedure are that there is no significant vessel trauma, with low failure and com-

plications rates, and thus relatively few interventions are required, he said.

Prof. Thompson also shared clinical experiences and initial findings from the FLEX study and the NEAT trial. FLEX is a single-center study of 33 patients conducted in Paraguay and completed in 2014.<sup>5</sup> Technical success was achieved in all cases; AVF patency at 6 months was noted in 96% of patients, and 96% of fistulas were usable for dialysis. The one fistula failure was due to central vein stenosis. Prof. Thompson described the only serious adverse event in which a patient moved his arm during the pAVF creation, resulting in a pseudoaneurysm.

NEAT is a prospective, multicenter, international study that enrolled 80 patients, including 20 patients in a roll-in phase and 60 in the study cohort. Patients were followed out to 12 months, with the primary endpoint (within 3 months) being the percentage of patients with fistula maturation/usability; secondary endpoints include safety (freedom from serious device-related adverse events), procedural success, patency, and patient satisfaction. In the study cohort, procedural success was 98.3%, and 91.2% of patients met the criteria for maturation, all very successful results for a trial such as this one, concluded Prof. Thomson.

In summary, Prof. Thomson said that the endovascular AVF procedure facilitates earlier and more frequent AVF creation, with the potential to decrease dependence on central venous catheters and possibly allow a patient to go to dialysis slightly earlier than with a surgical AVF. The result is highly reproducible and carries a low rate of complications and a high maturation rate in the experiences to date, based on the 6-month data currently available.

## KEY AUDIENCE QUESTIONS ON pAVF

The informal design and setting of the panel session allowed for a free exchange of questions and answers, with audience queries asking for more specifics on anatomic and procedural elements, but also global topics such as turf issues and what challenges pAVF may face in postapproval acceptance.

### Status of United States Clinical Trials

When asked about the status of future availability in the United States, Dr. Hull said that Avenu is about 90% of the way through its multicenter US clinical trial; Dr. Rajan indicated that TVA currently has CE Mark and Health Canada approval and is in discussions with the FDA to determine what is needed for clearance to market in the United States.

### Cost-Effectiveness

There is an assumption that pAVF procedures will result in significant cost savings to our health care sys-

tem. Prof. Thomson noted that there may be savings if the percutaneous procedure is done as an outpatient as compared with an inpatient procedure. Dr. Rajan agreed, noting lower failure rates and fewer interventions associated with the pAVF. Both felt that device costs would need to be considered but felt that even if device costs were high, pAVFs would still be cost-effective and the clinical benefits would tip the scales in favor of pAVF.

### Procedural Elements and Complications

One question from the audience focused on how long after pAVF creation the site can handle balloon angioplasty. Dr. Hull responded that this was initially a concern, but so far, they have been able to perform angioplasty soon after and have not yet had any issues. He recounted one case in a study in which he could not feel the fistula or hear it on using a stethoscope right after the procedure, so he accessed the radial artery and performed an angioplasty, noting that it has so far been the only maturation procedure that particular fistula required.

Prof. Thomson addressed a series of procedure-related questions, starting with the use of closure devices, which he described as successful in all but one case. After a failure using the Angio-Seal device (St. Jude Medical, Inc.), he noted a preference for the Exoseal (Cordis/Cardinal Health), with which he has not had any complications. He was also asked whether he employs a brachial plexus nerve block as does Dr. Hull. He indicated he uses midazolam and fentanyl intravenously.

More details on the incidence of ischemia, swelling, and hypertension were also queried. It was noted from the panel that venous hypertension and steal syndrome are also two big questions from regulators. However, classic venous hypertension of the hand has not yet been seen related to the fistula creation itself, said Dr. Hull. And, one reason the radial artery was chosen rather than the brachial is that it provides natural protection from steal, similar to a surgical AVF. He also believes the automated and consistent nature of the anastomosis creation reduces variation in its size and resultant flow.

Several conversations focused on the degree to which pAVF creation might interfere with or prevent optimal surgical AVF creation due to electing for an upper arm pAVF over a surgical creation at the preferred wrist location. Dr. Hull responded that if a patient is a candidate for a wrist fistula, that is what they receive. Dr. Rajan agreed, saying pAVF does not take away potential surgical sites with radial-cephalic, brachial-cephalic or brachial-basilic, and loop grafts, for example, still possible. Prof. Thompson recounted an experience in which, after a failed pAVF attempt, a surgeon was still able to use the forearm cephalic vein to create another fistula at the

wrist. Dr. Clement went into further detail to support the statement that pAVF does not take away the ability to do a surgical wrist fistula, describing how a perforating vein fistula does not involve tying off the vessel.

### **Multispecialty Implications of pAVF: A Wedge or a Bridge?**

A related area of discussion regarded when in the patient care spectrum pAVF will be considered and performed and who will perform it. Referring back to Dr. Sidhu's presentation, Dr. Hull estimated that most patients who have a temporary or permanent dialysis catheter placed do so in an interventional suite of some kind. Should pAVF become available, the patient could be mapped and evaluated for candidacy at that time, with pAVF possibly being performed that day, if appropriate.

However, an audience member suggested that if a patient is being referred for a fistula and is not a candidate for a radial AVF, the most likely scenario would be the surgeon electing for a brachial creation rather than referring the patient for pAVF if that surgeon does not perform the latter procedure.

This opened a series of comments regarding the challenges of creating and fostering a true multidisciplinary relationship. Dr. Sidhu described renal patients as being among those who can most benefit from multidisciplinary care, and he also believes that the successful implementation of this approach at his hospital has led to its particularly high volume of AVF creation.

"I know it sounds utopian and ideal, and it may not always be the reality," said Dr. Sidhu. "But, we work together and support each other, and we are happy to

let each other create AVFs surgically or endovascularly without fear of failure."

Dr. Hull agreed with the importance of a multidisciplinary approach, but stressed that nonsurgeons must learn to effectively map the AVF sites in order to determine candidacy. The sooner the AVF can be created, the more cycle time can be eliminated, reducing the patient's need for numerous visits with a variety of physicians, he said. Reduction in these visits and an increase in earlier AVF creations could also dramatically reduce the cost of care in this population. Subsequent discussions focused on patient preference, which favored pAVF in experiences the panel described, including some patients who opted for pAVF in lieu of open surgery and other patients who had a prior surgical AVF failure and preferred the pAVF approach. More data will better inform this process, noted Dr. Sidhu.

Prof. Thomson noted tremendous support from the renal physicians at his hospital, leading him to think it is "inevitable" that AVFs will increasingly trend toward percutaneous placement. He also spoke to the importance of open communications with everyone involved in the patient's care on the known downsides of conventional AVF creation and potential advantages of a percutaneous approach. ■

1. Hull JE, Balakin BV, Kellerman BM, Wroldstad DK. Computational fluid dynamic evaluation of the side-to-side anastomosis for arteriovenous fistula. *J Vasc Surg.* 2013;58:187-193.
2. Krishnamoorthy MK, Banerjee RK, Wang Y, et al. Hemodynamic wall shear stress profiles influence the magnitude and pattern of stenosis in a pig AV fistula. *Kidney Int.* 2008;74:1410-1419.
3. Bharat A, Jaenicke M, Shenoy S. A novel technique of vascular anastomosis to prevent juxta-anastomotic stenosis following arteriovenous fistula creation. *J Vasc Surg.* 2012;55:274-280.
4. Lo Monte AI, Damiano G, Mularo A, et al. Comparison between local and regional anesthesia in arteriovenous fistula creation. *J Vasc Access.* 2011;12:331-335.
5. Rajan DK, Ebner A, Desai SB, et al. Percutaneous creation of an arteriovenous fistula for hemodialysis access. *J Vasc Interv Radiol.* 2015;26:484-490.