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TECHNICAL NOTE VENOUS INTERVENTIONS

Outcomes of Wrist-Access Deep Venous Embolization Following Percutaneous Fistula Creation: A Two-Year Single Center Experience

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Abstract
Purpose During percutaneous arteriovenous (pAVF) fistula creation, deep venous embolization is recommended to encourage superficial venous flow development. The safety of crossing adjacent to the newly formed fistula from wrist venous access has not been established. The purpose of this study was to evaluate the safety and efficacy of antegrade deep venous embolization after creation of the pAVF.
Materials A retrospective analysis was performed of all procedural data related to pAVF creation using the Wavelinq device from October 2019 to November 2021. Patient data from the hospital information systems were collected where the venous access for fistula creation was from the wrist-access (ulnar or radial vein) and where deep venous embolization was performed after forming the fistula and crossing adjacent to the anastomosis. Thirty-nine patients were identified.
Results Twenty pAVFs were created from wrist ulnar vein access and 19 from radial vein access. The accessed veins were used for embolization of the brachial veins central to the newly created anastomosis. No pAVFs were lost by crossing adjacent to the anastomotic area to perform deep venous embolization at time of creation. There were no major complications, specifically bleeding, infection, pseudoaneurysm formation. Rates of minor complications consisted of two coil migrations to the right atrium requiring uneventful retrieval (5%). Follow-up ultrasound data showed no evidence of delayed complications.
Conclusion In this single center experience crossing alongside the anastomosis of a newly formed percutaneous fistula from an antegrade venous approach was safe with no risk of loss of the pAVF.

Keywords Percutaneous · Endovascular · Fistula · Dialysis · Embolization · Anastomosis

Introduction

While the techniques for surgical creation have been well described and vetted thoroughly over more than 50 years, percutaneous arteriovenous fistula (pAVF) creation is relatively new and the techniques for successful creation are less well understood and scrutinized [1]. The Wavelinq system (Becton Dickenson, Franklin Mills, NJ) allows for pAVF creation at multiple sites in the arm, which in turn establishes a larger network of deep veins exposed to systemic arterial flow. As such, venous embolization has been widely accepted and recommended within the instructions for use at the index procedure to promote superficialization of flow and maturation for cannulation.

The technique for deep venous embolization at the index procedure for Wavelinq pAVF creation has been described by the company as a procedure performed retrograde from arm venous access and without crossing alongside or through the newly created anastomosis. This can be done

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before or after fistula creation. The concern is that any manipulation/irritation of the anastomosis or vessels at the anastomosis creates the potential for damaging or disrupting the newly formed pAVF. However, this recommended practice is anecdotal.

The current analysis aimed to evaluate the safety of performing deep venous embolization from an antegrade wrist-access vein (radial and ulnar) approach after creating the pAVF and passing along-side the anastomosis.

Material and Methods

This was a single-center, retrospective review of Wavelinq procedures performed from October 2019 through November 2021. Institutional review board approval was not required. 76 Wavelinq fistulas were created of which 59 were embolized. Of those, 39 had wrist venous access with embolization performed from the wrist vein access and 20 from another venous access site (based on inability to access the desired vein for embolization from the wrist access often due to variations in venous anatomy). The remaining 17 patients were not embolized (Table 1). All procedures were performed by a single operator with 13 years of experience. All patients who met the instructions for use criteria who subsequently had pAVFs performed with venous delivery of the venous component of the device from the wrist-side of the fistula were included. Deep venous embolization was required for all 39 cases to promote superficial venous flow. All embolizations were done after pAVF creation during the index procedure. Patient demographics are summarized in Table 2. Procedures were performed as outpatient procedures with conscious sedation and an ultrasound guided supraclavicular brachial plexus block by the same operator.

Embolization Technique

After digital subtraction angiography (DSA) confirmed pAVF creation, the arterial and venous 4 French (Fr) Wavelinq catheters were removed from their respective sheaths. The 0.014″ 80 cm wire (Galt, Garland, TX) had been withdrawn from the fistula location prior to formation of the anastomosis, however, was left through the valve of the sheath. Over the 0.014″ wire, a 4 Fr 0.035″ Kumpe catheter (Merritt Medical, Salt Lake, UT) was advanced into the peripheral portion of the respective radial or ulnar vein, distal to the anastomosis. The 0.014″ wire was exchanged out for a 150 cm V18 wire (Boston Scientific, Natick, MA). The V18 wire carefully advanced through the vein and alongside the anastomosis until it reached centrally/above the elbow into the desired brachial vein. The 4 Fr Kumpe catheter moved very freely along the V18 wire with no obvious buckling or catching at the AV anastomosis.

Embolization Device Characteristics

Pushable Nester and Tornado coils 5–10 mm (Cook Medical, Bloomington, IN) and Caterpillar occlusion devices (Becton Dickenson, Franklin Mills, NJ). The decision on which device to use and how many devices to use was based on the operators experience and DSA criteria after pAVF creation which were a large lateral brachial vein seen originating directly from the perforator vein and/or flow preferentially into the deep venous system over the superficial venous system or no flow into the superficial veins after formation of the pAVF. Coil and Caterpillar sizing was approximately 20% oversized to vein diameter.

Pushable 0.035″ coils and detachable devices were then deployed, and DSA performed to ensure occlusion. When a Caterpillar device was used, the 4Fr catheter was exchanged out over a 0.035″ wire and replaced with a 0.038″ 5 Fr Kumpe catheter for Caterpillar device delivery and deployment.

Patients were monitored for procedural and anesthesia complications for 2–3 h after the procedure and sent home with the arm in a sling and a reminder to limit limb utilization for a couple days.

Ultrasound (US) Evaluation and Outcomes Evaluation

At the time of pAVF creation, an ultrasound of the anastomosis and access sites was performed as well as 2 and 6 weeks after creation as part of a more comprehensive examination which included assessment of flow in the brachial artery and outflow vein diameters and flow rates.

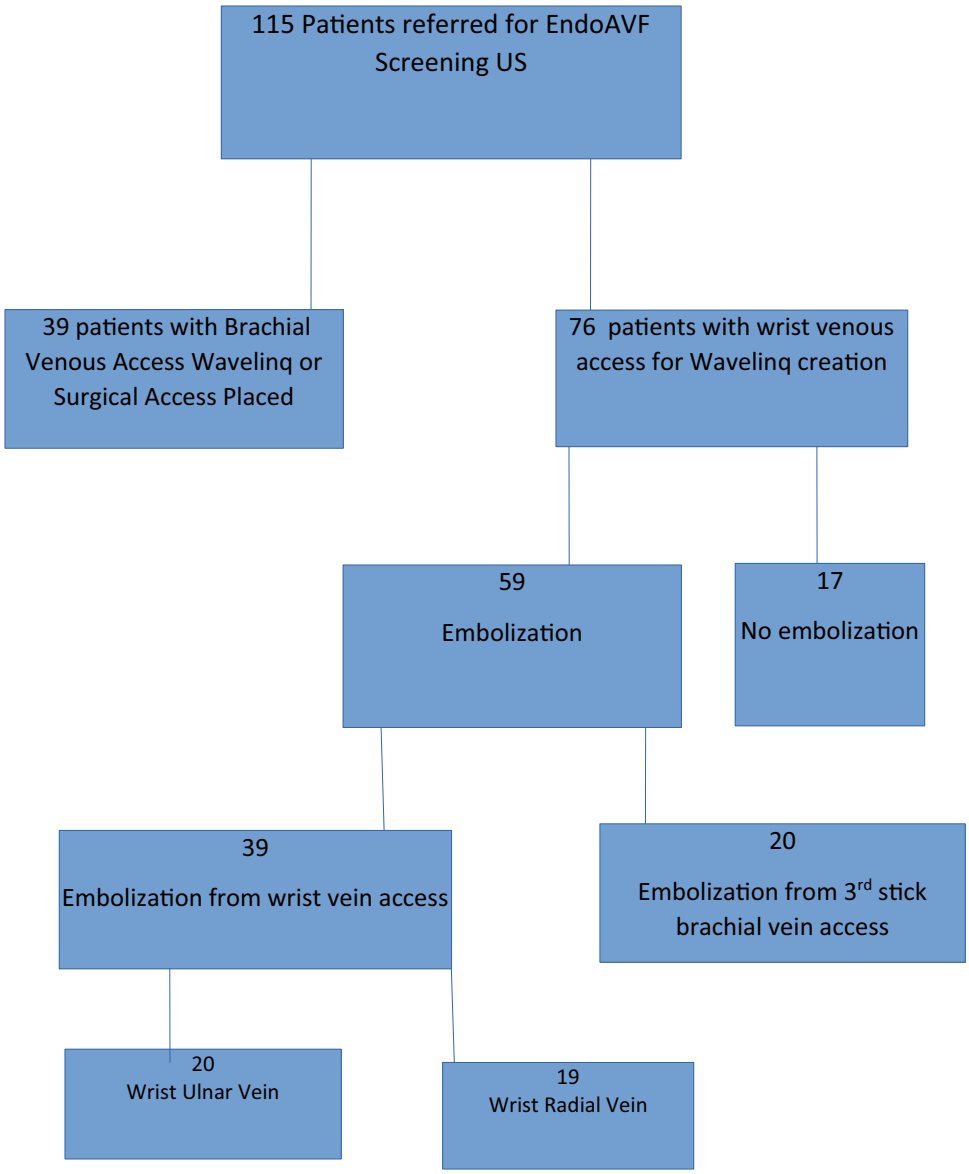
Clinical physical exam was also performed at completion of the procedure and at 2 and 6 weeks for patients. Physical exam included palpation of the fistula and outflow veins and assessment of the arm for swelling, tenderness or other physical findings.

Minor and major complications were recorded in each patient and included fistula closure, coil migration, hematoma, infection and pseudoaneurysm formation.

Results

All the fistula creation procedures were technically successful (100%) with arterialized flow into the deep and superficial venous system. Ulnar vein access was established in 20 patients and radial venous access in 19 patients. The accessed vein in the wrist was 15 in the lateral ulnar vein, 5 in the medial ulnar vein and 19 in the lateral

Table 1 Patients referred for endAVF creation and subsequently included in the study



radial vein. The location of the fistula was proximal radial artery to lateral radial vein in 19, common ulnar artery to lateral ulnar vein in 16, common ulnar artery to medial ulnar vein in one and proximal proper ulnar artery to lateral ulnar vein in 3. Average procedure time excluding the nerve block was 76.7 min (range 23–183 min) measured from needle stick to hemostasis. Average fluoroscopy time was 14.2 min (range 5.3–46.5 min).

No embolization was performed from the arterial access and through the arteriovenous anastomosis. Pushable coils were used in 26 patients and detachable occlusion devices used in 16 (Figs. 1, 2). Three patients required additional coil placement peripheral to the occlusion device to treat large bridge veins remaining where considerable arterial flow was still being lost to the deep venous system.

Two of the patients in which pushable 7 mm Tornado coils were used in the deep brachial veins after fistula formation, had coils migrate centrally into the patient's right atrial appendage. These were both removed with ultrasound guided common femoral vein access and snare removal. There were no complications associated with removing the coils. Coil undersizing and the high arterialized flow of the deep venous system both contributed to

Table 2 Patient demographics: of 59 patients that were embolized during the index procedure

Characteristic	Number
Baseline patient demographics and pAVF characteristics	
Patients	59
Male	47
Female	12
Age (mean)	65
Hypertension	48
Diabetic	38
Smoker (current or former)	33
Hyperlipidemia	25
On dialysis	42
Months on dialysis (mean)	8
Pre-dialysis	17
pAVF characteristics	
Left	33 (56%)
Right	26 (44%)
Venous access for creation	
Radial vein	27 (46%)
Ulnar vein	26 (44%)
Brachial	6 (10%)
Arterial access for creation	
Radial	25 (42%)
Ulnar	20 (34%)
Brachial	14 (24%)
Embolization access veins	
Other	20 (34%)
Radial vein	20 (34%)
Ulnar vein	19 (32%)

this occurrence. This also prolonged the procedure times in these patients.

All patients except three, were seen for US follow-up scan at 2 and/or 6 weeks. One patient died 10 days after fistula placement at an outside hospital due to a gastrointestinal bleed. Two other patients did not follow-up for any scans and were lost to follow-up. Brachial artery flow rates averaged 1031 ml/min (range 62–2906). Cephalic vein flow rates averaged 423 ml/min (range 55–974). Basilic vein flow rates averaged 360 ml/min (range 11–902). The low flow values observed within the ranges were in a single patient with a severe juxta-anastomotic stenosis 3 days after creation, noted by a loss of thrill on clinical examination. The stenosis was treated with 4 mm cutting balloon PTA with salvage of the pAVF. There were no complications seen on follow-up scans.

US evaluations performed at follow-up showed no evidence of pseudoaneurysm, hematoma, or other complication in the remaining 35 patients nor the 20 patients with other venous access sites.

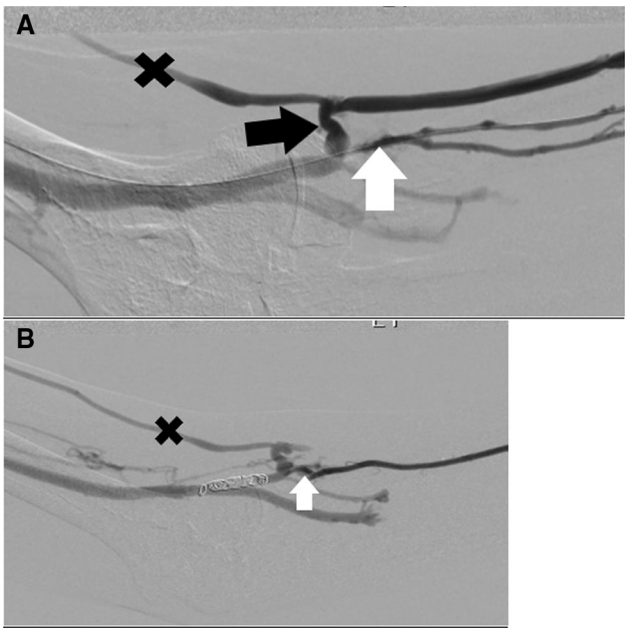


Fig. 1 Pre-(**A**) and Post-(**B**) coil embolization of the peripheral left lateral brachial vein via the left lateral radial vein. Injection in (**A**) is from the left lateral radial vein. Injection in (**B**) is from the left wrist radial artery. X-cephalic vein, black arrow-venous perforator, white arrow-location of pAVF

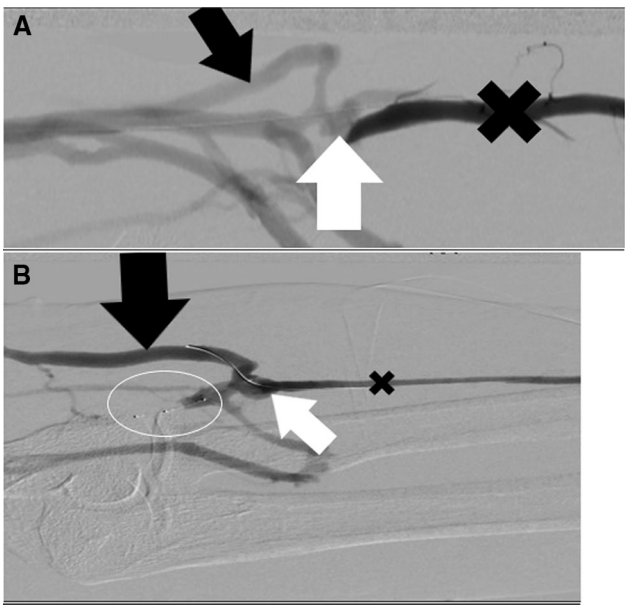


Fig. 2 Pre-(**A**) and Post-(**B**) Caterpillar embolization of the peripheral right lateral brachial vein via the right lateral radial vein. Improved opacification of the cephalic vein with decreased flow into deep veins seen on the post-embolization image. Injection is from the right wrist radial artery. X-radial artery, black arrow-cephalic vein, white arrow-location of pAVF. White circle-Caterpillar device

Discussion

PAVF creation is a relatively new technique with initial and larger studies pointing to rates of creation and use that exceed 80% [2–5]. However, the procedures themselves are relatively in their infancy with advances and refinements in techniques likely to evolve soon. Up to this point, there has been no published data to describe the intrinsic stability of the newly formed anastomosis of the Wavelinq fistula in a group of patients where the fistula location was traversed immediately after formation [6–8]. Herein, we have described 39 fistulas that had both 4 Fr and 5 Fr catheters placed alongside the anastomosis and into the deep venous system, through which coils and occlusion devices were placed for adjunctive embolization. We witnessed no disruptions of the fistula during or after this maneuver, which would presumably be manifested as bleeding, hematoma, pseudoaneurysm formation or loss of the fistula.

Despite not having a large cohort of procedural data, this single center experience suggests that the pAVF Wavelinq anastomosis is more stable and less susceptible to injury than hypothesized based on no stabilization or securement device left at the site of anastomotic creation. Careful manipulation of wires and catheters through the veins that are part of the anastomosis can certainly be considered as a reasonably safe technique. The use of this technique during Wavelinq creation has three benefits. First, an additional more central venous access is not required to embolize the brachial vein if wrist venous access was established at the outset of the procedure. Second, with more peripheral access anatomic evaluation of the forearm and arm veins (both deep and superficial) is more complete. And third, the overall procedure time may be shorter.

Limitations of the study are the relatively small patient size, single center, single operator experience and retrospective collection of data. Also, a true comparison group was not possible.

In conclusion, embolization of the deep venous system following pAVF creation from wrist venous access was safe with no noted immediate or short-term damage.

Author Contributions All authors contributed to the study conception and material preparation, data collection. Analysis was performed by Brandon Repko and Dheeraj Rajan. The first draft of the manuscript was written by Brandon Repko and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript. Robin Stiner RN and Jenny Kopp RN contributed to the data collection.

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Declarations

Conflict of interest All authors declare that they have no conflict of interest.

Ethical Approval Because this study was a retrospective chart review, patient consent was waived, and an opt-out method was used instead. The study protocol was reviewed and institutional review board approval was deemed unnecessary.

Informed Consent Because this study was a retrospective chart review, patient consent was waived, and an opt-out method was used instead.

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