

Optimizing Hemodialysis Cannulation Methods

Techniques and strategies to preserve vascular access.

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A functional vascular access is vital for hemodialysis. The goal of cannulation is to gain entry into the patient's vascular access without causing damage to the patient's lifeline. Some of the common issues associated with cannulation can lead to serious vascular access complications. Solutions and steps to prevent and treat these issues are reviewed in this article. The National Kidney Foundation (NKF) Kidney Disease Outcomes Quality Initiative (KDOQI) Vascular Access Guidelines support the cannulation information, and the full text of the guidelines is available on the NKF Web site at www.kidney.org.¹

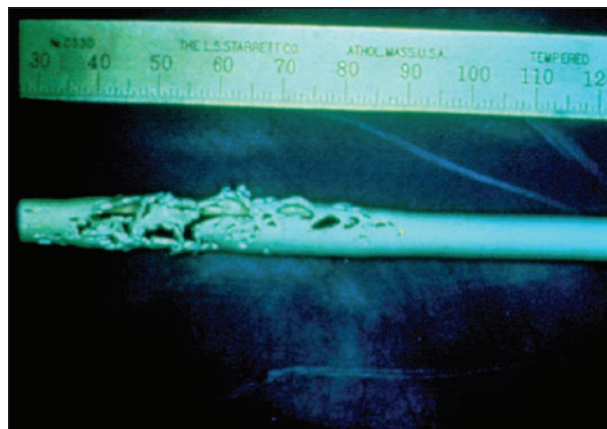
INTRODUCTION

A typical hemodialysis patient undergoes a dialysis session three times per week, every week of the year. If every arterial and venous needle cannulation is successful, the minimum number of yearly needle insertions is 312. Because of the high volume of needle insertions, the site selection for each cannulation is paramount in the preservation of the vascular access. Native veins used to create an arteriovenous fistula (AVF) and synthetic materials, such as PTFE, used to create an arteriovenous graft (AVG) can both be damaged from repetitive cannulation in the same general puncture area (Figure 1). The term *one-site-itis* is used to describe repeated, limited cannulation in the same area and related damage to the conduit. With one-site-itis and other poor cannulation techniques, there is risk of damage to the access. Aneurysm formation can occur in an AVF, and a pseudoaneurysm can occur in an AVG. Large areas of pooled blood may change the flow dynamics of the access, creating more turbulence. Increased turbulence may cause damage to the vessel walls, which can result in cell proliferation and stenosis. If damaged areas are not repaired with surgery or endovascular techniques, dialysis treatment quality will be affected.

QUICK AND EASY ASSESSMENT OF AN AVF

A physical examination of the vascular access will identify the areas of aneurysm/pseudoaneurysm formation, as well

as any upstream stenosis normally found once the damaged area shows shape distortion or in tortuous areas of the access (Figure 2). Assessment must be done before each cannulation to ensure proper site selection. The Free Fistulagram is a simple test to find stenosis in fistulae. To perform this test, have the patient raise the vascular access arm (similar to hand raising to ask a question), and the AVF should at least partially flatten and soften. If the fistula remains engorged, a stenosis is likely above the site where the vein does not flatten (Figure 3). The stenosis acts like a dam and backs up the blood in the distended vein area. This simple test can be performed at the dialysis center and before or after any endovascular procedure to evaluate the vascular access and document the findings. After successful treatment of a stenosis, the AVF should flatten with the patient's arm raised. The findings can be documented and shared with the patient and the referring dialysis unit. Should the stenosis reoccur, the abnormal finding will reoccur and trigger a referral back to the endovascular laboratory for re-evaluation.



(Image courtesy of W. L. Gore & Associates)

Figure 1. Pseudoaneurysm in an AVG due to lack of proper needle site rotation. The PTFE material is damaged from the cutting edge of the AVF needle, and the material cannot repair itself.



Figure 2. AVF with multiple aneurysm formations.

ONE-SITE-ITIS

An inability to properly assess access and select needle insertion sites can lead to the same puncture site being used repeatedly. A possible reason for the development of this one-site-itis is linked to the lack of proper staff and patient education. Patients may request the same general area for the arterial and venous needle cannulation sites, and if the dialysis staff does not take the time to explain proper cannulation techniques to the patient, the limited area will be used again and again. Over time, scarring occurs, and the nerves in the limited cannulation area are damaged; thus, the patient experiences less pain when the needle cannulation is performed in the same limited area. Both staff and patients also select the same limited area because that area was successfully used for the last hemodialysis treatment. If they lack training and confidence, staff and patients may feel using the same area will increase the chance of a successful cannulation. With education, training, and certification, the downward spiral leading to one-site-itis and subsequent access damage can be avoided. Chronic hemodialysis facilities that receive payment for dialysis from CMS are expected to comply with the conditions for coverage for end-stage renal disease (ESRD) facilities. Hemodialysis patient care technicians (PCTs) are now required to successfully pass a national, commercially available, standardized certification examination within 18 months of their employment as a PCT. The state-level boards of nursing determine if the PCTs can cannulate a hemodialysis vascular access. In the majority of states, PCTs can and do perform the routine hemodialysis cannulations. The certification requirement

will help ensure that the PCTs performing the vascular access cannulations possess a minimum knowledge base of vascular access and theory of cannulation. The certification does not reflect cannulation competency but does ensure that PCTs obtain certification within 18 months to remain employed in the nephrology community. Before the update, the baseline knowledge for PCTs was a high school diploma or equivalent. These two updates to the conditions for coverage for ESRD facilities should help to improve the quality of cannulation care hemodialysis patients receive within the US.

Figures 4 and 5 show a graft pseudoaneurysm with stenosis. Note the highly darkened area at the base of the lower cannulation zone, indicating one-site-itis (Figure 4). Figure 5 shows the associated radiological image. Figures 6 and 7 show a rapidly formed graft hematoma and pseudoaneurysm due to traumatic cannulation. This type of injury can be avoided with proper training and education. Figure 8 shows an AVF that was cannulated prematurely at a dialysis center, causing a rapidly enlarging infiltrate that threatens the life of the access as well as the life of the limb. Figure 9 shows an AVF image of multiple stenosis.

RISKS AND COMPLICATIONS OF POOR CANNULATION

Recently, serious risks from rupture of one-site-itis areas of a vascular access have been identified by the Maryland Chief Medical Examiner and the Centers for Disease Control and Prevention (CDC) and presented at the American Society of Nephrology Renal Week 2008. The

Maryland Chief Medical Examiner, Donna Vincenti, MD, noted 24 cases of dialysis patient deaths by exsanguinations or vascular access hemorrhage between 2000 to 2006.² The CDC was consulted to help evaluate the root cause for the deaths. The Centers for Medicare & Medicaid Services (CMS) database was used to identify the ESRD death notification codes including those for hemorrhage from vascular access, hemorrhage from dialysis circuit, and hemorrhage from ruptured vascular aneurysm. In reviewing the data, the investigators found 84% of the deaths occurred after a spontaneous vascular access rupture. Only 5% occurred from needle dislodgement/separation during the hemodialysis treatment. Perforation during a medical procedure occurred in 11% of the deaths.³ All members of a vascular access team should help educate peers and patients about potential life-threatening vascular access ruptures.



Figure 3. During a physical examination, the entire AVF does not flatten when the arm is raised and indicates upstream central stenosis.

Prevention of one-site-itis and proper treatment of an aneurysm/pseudoaneurysm formation needs to be implemented to decrease the risk of death from vascular access rupture. Therefore, the interventionist must take extreme care when cannulating or performing an endovascular procedure on a vascular access with an aneurysm/pseudoaneurysm formation due to the increased risk of rupture and resulting hemorrhage.

(Image courtesy of Vascular Access Centers, LLP.)

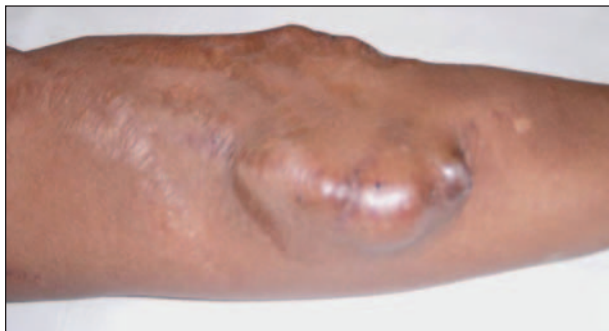


Figure 4. An AVG with pseudoaneurysm and stenosis.

Communication Between the Endovascular Lab and Dialysis Facilities to Prevent Aneurysm-Related Complications

The old adage, "An ounce of prevention is worth a pound of cure," is certainly true for the prevention of aneurysm/pseudoaneurysm formations. Proper cannulation site rotation must be implemented with the initial cannulation and continue for the life of the vascular access. Proper documen-

(Image courtesy of Vascular Access Centers, LLP.)

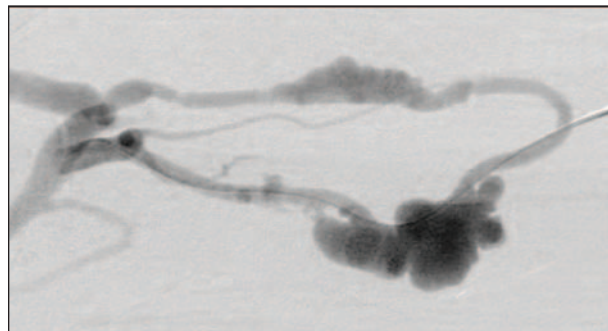


Figure 5. Radiological image of an AVG with pseudoaneurysm and stenosis.

(Image courtesy of Vascular Access Centers, LLP.)

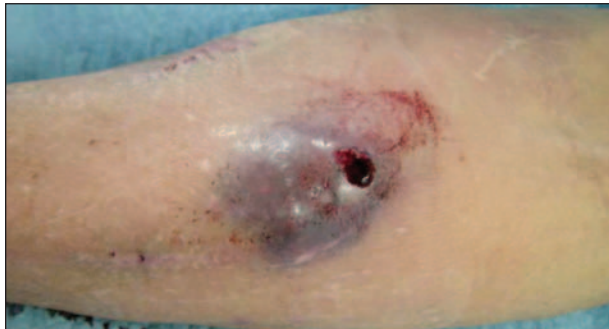


Figure 6. An AVG hematoma and pseudoaneurysm due to traumatic cannulation.

(Image courtesy of Vascular Access Centers, LLP.)

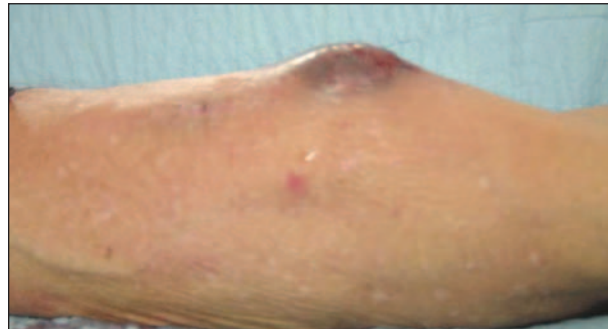


Figure 7. An AVG hematoma and pseudoaneurysm due to traumatic cannulation (side view).

(Image courtesy of Vascular Access Centers, LLP.)



Figure 8. An AVF that was cannulated prematurely at a dialysis center.

(Image courtesy of Vascular Access Centers, LLP
Dr. Sandeep B. Sharma.)

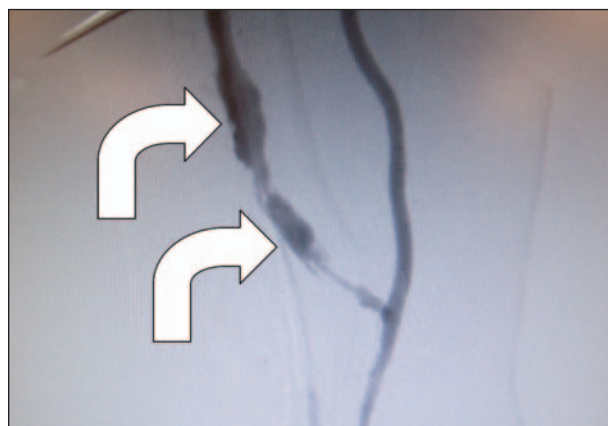


Figure 9. Two one-site-itis cannulation zones potentially causing aneurysm and stenosis.

(Image courtesy of Vascular Access Centers, LLP.
Dr. James McGuckin.)

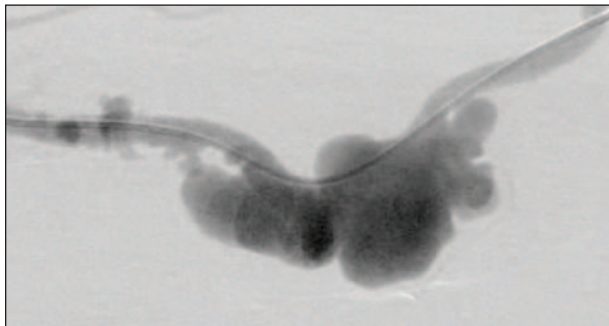


Figure 10. A closer view of medial cannulation zone of left forearm AVG.

tation of each cannulation, including location of the arterial and venous needles, will help ensure site rotation over the entire vascular access. The dialysis facility medical information system should contain an easy-to-use image to chart the needle locations. If the computerized documentation system does not accommodate a drawing or image of the vascular access, a paper image of the vascular access can be used to chart needle location, needle direction, date, name of the person performing the cannulation, and any cannulation issues.

Procedural images (pre- and postendovascular procedures) should be shared with the dialysis unit so the dialysis vascular access record can be updated. Any area that should not be used for cannulation due to stenosis, stents, or any other structural issues (such as depth greater than can be accessed with standard needle size of 1 inch) need to be documented clearly on the images and communicated to the patient and referring dialysis unit. Once available, a written report should be shared with the referring dialysis unit. The dialysis facilities are recommended to keep a clear and accurate vascular access history. The referring dialysis unit should also share any previous vascular access documentation as part of the referral to the endovascular lab. The dialysis facility consent allows transfer of information required for the endovascular lab to properly treat the dialysis patient. The endovascular lab consent should also include wording to allow the procedure images and written reports to be shared with the referring dialysis facility. Patients have the right to receive a copy of their records for their own record keeping or to share with other treating physicians as they deem necessary for their overall healthcare. Sharing information about vascular access between disciplines helps to ensure safe care and access preservation.

PATIENT ROLE IN VESSEL PRESERVATION

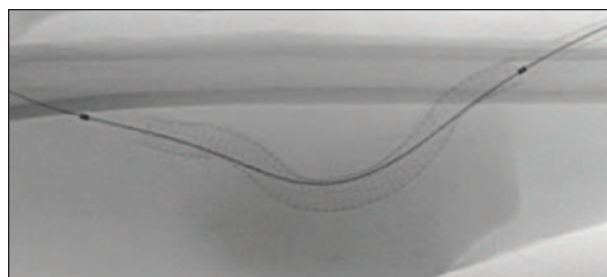
The conditions of coverage discussed earlier have recently been updated to include the patients' right to learn and perform self-cannulation of their vascular access. The patient as

the primary cannulator is the easiest way to ensure proper cannulation and site rotation. Patients can be trained to perform cannulation of their AVF or AVG as part of vessel preservation. Chronic kidney disease stage 3 and 4 patients are now being taught to preserve their nondominant arm for future vascular access. The vessel preservation includes use of the dorsum of the hand for venipunctures and IV infusions. The use of the cephalic vein of either arm for blood draws, IV fluid therapy or drug infusions, or the use of subclavian catheters and peripherally inserted central catheter (PICC) lines is contraindicated due to the risk that the vein used for the venipuncture will stenose and limit future vascular access sites. The NKF KDOQI supports vessel preservation. The full-text guidelines are available on the NKF Web site at www.kidney.org.¹ Recently, the Fistula First Breakthrough Initiative Coalition published two documents, "Vein Preservation and Hemodialysis Fistula Protection" and "Recommendations for the Minimal Use of PICC Lines" on the Web site www.fistulafirst.org that details the vessel preservation strategy. The American Society of Diagnostic and Interventional Nephrology also published a position statement on vessel preservation and the document is posted on its Web site www.asdin.org.⁴

Patients performing self-cannulation is the ideal cannulator because they can feel the needle in their hand as they advance the needle, as well as feel the needle enter the skin, subcutaneous tissue, and the vessel. The patient quickly becomes an expert cannulator of his or her own vascular access and can easily track his or her cannulation site rotation. Patients with AVFs can use the buttonhole cannulation technique to self-cannulate their vascular access.

ROLE OF BUTTONHOLE CANNULATION IN ACCESS PRESERVATION

The buttonhole technique is the use of a single needle tunnel track and a single vessel wall puncture site for the arterial needle and a separate site for the venous needle. Unlike one-site-itis, in which a limited area is punctured over and over again, the buttonhole needs to be a single tunnel track (like a pierced earring tunnel track) and a single vessel flap that mates perfectly with the AVF needle. Like a pierced earring, the tunnel track is created with a sharp cutting AVF



(Image courtesy of Vascular Access Centers, LLP.)

Figure 11. The deployed covered stent.

(Image courtesy of Vascular Access Centers, LLP.)

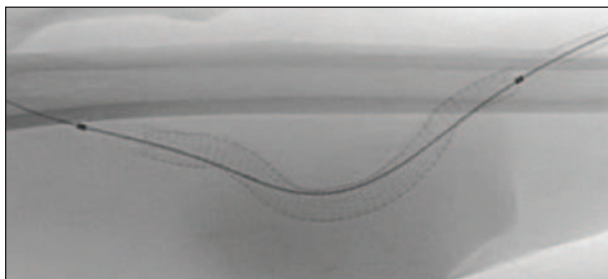


Figure 12. This particular stent, the Gore Viabahn (W.L. Gore & Associates, Flagstaff, AZ), must be sealed at both ends with corresponding angioplasty balloon.

needle. After a very limited number of cannulations (six to 10), the tunnel track forms scar tissue, and a noncutting buttonhole needle can be used for cannulation. The vessel flap forms very quickly, and care must be taken to only create a single vessel flap. If prolonged use of a standard AVF is used, the tissue tunnel track as well as the vessel flap can be cut and damaged, leading to failure of the buttonhole sites. The buttonhole needles are dull and cannot cut new subcutaneous tissue or vessels, and thus, the cannulation procedure-related pain is reduced or eliminated for the patient. The buttonhole cannulation requires strict adherence to proper infection control techniques. The cannulation site will form a

normal scab over the buttonhole site postcannulation. The skin must be cleaned before the scab removal and again after the scab is removed and before the AVF needle is inserted into the tunnel track and vessel flap. The scab removal needs to be done in a manner that lifts off the scab but does not cause tissue trauma and bleeding at the buttonhole site.

If a patient with buttonhole cannulation sites presents to the endovascular lab, the buttonhole sites should not be used as the point of entry into the AVF. Any required puncture sites should be away from the buttonhole needle tunnel track and vessel flap to prevent damage to the buttonhole sites. The Fistula First Breakthrough Initiative Coalition has published an educational video entitled, "Cannulation of the Arteriovenous Fistula (AVF)." A copy of the DVD was provided to every US chronic hemodialysis facility in 2007. The video is also available on the Web site www.fistulafirst.org for anyone to view. A comprehensive companion PowerPoint slide deck is also available on the same Web site. Please refer to the Fistula First Web site and the NKF Web sites for complete information about the proper technique for the buttonhole cannulation technique for use only in AV fistulae.

TREATING COMPLICATIONS

Treatment of AVG and AVF complications are detailed in the KDOQI Vascular Access Guidelines.⁵ The use of stents

(Image courtesy of Vascular Access Centers, LLP.)

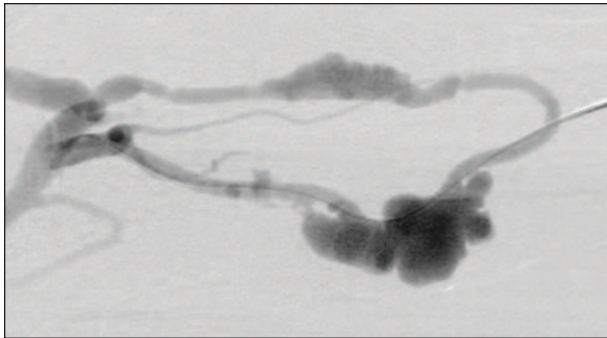
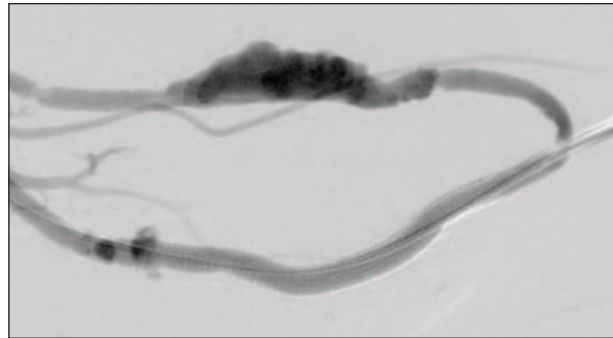


Figure 13. Before the procedure.

to treat aneurysm/pseudoaneurysm formation is referenced in the rationale as a possible option. The KDOQI recommended treatment is surgical revision and repair. However, this is not always a viable option. Possible reasons include, but are not limited to, limited access and coagulopathy. Covered stents on the market are being used successfully and are being studied in this area. More work must be done, and we encourage the endovascular professionals to pursue FDA approval. Currently, none of the stents are cleared by the FDA for use within the cannulation zones of dialysis access. The stent walls may not accommodate puncture from a large-gauge AVF needle. This can lead to metal portions of the stent rupturing through the AVG or AVF vessel wall and into the subcutaneous tissue. With the stent wall integrity broken, segments of the metal could also break free into the bloodstream.

Before FDA approval for cannulation, the designs would need to be tested to ensure the stent could withstand needle puncture. Currently, if a stent is used in an off-label manner (in a cannulation zone), the cannulation of the vascular access through the stent must be ordered by the placing physician. A physician order is required for off-label use of a medical device by the other members of the health-care team. Clear documentation of the stent placement site and allowable use should be included with a report to the referring hemodialysis facility. If a stent is placed as part of endovascular therapy, an informed consent explaining the off-label use to the patient should occur. If used to treat a ruptured vessel during an angioplasty procedure, the potential use should be part of the angioplasty consent. As with any implantable device (including tunnel hemodialysis catheters), the patient should be given documentation that includes the name of the device, manufacturer, and model/lot number. Patients should have this information for future reference if they have an MRI, or if the FDA recalls the device.

Figures 10 to 14 demonstrate the use of covered stents to treat graft-related pseudoaneurysms. The treated access is pictured in Figures 4 and 5.



(Image courtesy of Vascular Access Centers, LLP.)

Figure 14. After the covered stent insertion.

SUMMARY

Dialysis vascular accesses are vital and are cannulated frequently. When poorly performed, cannulations can lead to complications, specifically aneurysm/pseudoaneurysm and stenosis, which affect the life of the access. When complications occur and are treated with off-label devices, the information should be shared with all involved. Doctors, nurses, PCTs, and patients all have a role in vessel preservation during dialysis. Members of the vascular access team must also work together throughout the continuum to ensure successful creation, maturation, care, and maintenance of the chronic kidney disease stage 4 and 5 patient's vascular access lifeline. Having regular cannulation training and discussion within the multidisciplinary team in your unit area or region will ensure that current guidelines and recommendations are always observed and followed. ■

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