

CORE CURRICULUM IN NEPHROLOGY

Interventional Nephrology: Core Curriculum 2009

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INTRODUCTION

Vascular access care has evolved significantly during the last decade since the National Kidney Foundation's original Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines were published in 1997. These guidelines identified both evidence-based and opinion-based recommendations to improve vascular access outcomes in the United States. Interventional nephrology has developed in parallel and is now emerging as a distinct nephrology subspecialty. Box 1 shows historical highlights within the context of the field as a whole. The continued success of interventional nephrology requires the commitment of academic training centers. At present, the program requirements for residency education in nephrology lack sufficient detail to adequately prepare trainees for interventional procedures. As a result, a graduating nephrology trainee's vascular access knowledge frequently is inadequate to provide optimal care to patients with kidney failure. As a developing subspecialty of nephrology, interventional nephrology must become an integral part of the nephrology training

experience. Nephrology training programs need to become actively engaged in modifying the training to include, at a minimum, core vascular access knowledge for each trainee. These needs have been partially addressed in previous Core Curricula appearing in the *American Journal of Kidney Diseases*; namely, an article from Maya and Allon on vascular access (April 2008) and an article from O'Neill and Baumgarten on diagnostic ultrasonography (September 2003); both articles are freely available at www.ajkd.org.

Interventional nephrologists have a pivotal role to play, working in concert with general nephrologists, interventional radiologists, and vascular surgeons to optimize care of dialysis patients. This Core Curriculum on interventional nephrology is designed for nephrologists who wish to make interventional nephrology a major career focus. It is based on the curriculum adopted by the American Society of Diagnostic and Interventional Nephrology (ASDIN) and the training manual developed by Dr Gerald Beathard.

EPIDEMIOLOGY

Until recently, vascular access was a leading cause of hospitalization (>20%) in the end-stage renal disease population. With an increasing number of vascular access procedures being performed in outpatient settings, there has been a greater than 35% decrease in hospital admissions related to vascular access for hemodialysis patients.² Nephrologists are now performing an increasing number of interventions to minimize the morbidity and mortality associated with vascular access complications.² Appropriately trained interventional nephrologists can perform these procedures in a safe and effective manner: in 2004, Beathard and Litchfield

Box 1. Highlights in Interventional Nephrology

- 1924 First hemodialysis performed by George Haas
- 1960 First long-term vascular access (Quinton-Scribner shunt); shunt thrombectomy managed by nephrologists
- 1966 First internal shunt (Brescia-Cimino fistula)
- 1990s Interventions in vascular access by nephrologists (pioneered by Gerald Beathard)
- 1997 K/DOQI Vascular Access Guidelines (latest KDOQI update, July 2006)
- 2000 Renal Physicians Association/American Society of Nephrology position paper on interventional nephrology credentialing
- 2000 ASDIN founded with aim "to promote the proper application of new and existing procedures in the practice of nephrology with the goal of improving the care of nephrology patients"
- 2005 ASDIN First Annual Scientific Meeting
- 2007 ASDIN adopts Core Curriculum based on Dr Gerald Beathard's *Training Manual for Interventional Nephrology*

Abbreviations: ASDIN, American Society of Diagnostic and Interventional Nephrology; KDOQI, Kidney Disease Outcomes Quality Initiative.

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reported that more than 14,000 procedures had been performed by interventional nephrologists, with success and complication rates of 96% and 3.5%, respectively.

ADDITIONAL READING

1. American Society of Diagnostic and Interventional Nephrology: Education and training. Available at: <http://www.asdin.org>. Accessed January 1, 2009
2. US Renal Data System: USRDS 2008 Annual Data Report. The National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2008
3. Accreditation Council for Graduate Medical Education: ACGME Program Requirements for Fellowship Education in the Subspecialties of Internal Medicine. Available at: http://www.acgme.org/acwebsite/rrc_140/140_prindex.asp. Accessed May 8, 2009
4. Maya ID, Allon M: Vascular access: Core curriculum 2008. *Am J Kidney Dis* 51:702-708, 2008
5. Asif A, Byers P, Vieira CF, Roth D: Developing a comprehensive diagnostic and interventional nephrology program at an academic center. *Am J Kidney Dis* 42:229-233, 2003
6. Asif A: Interventional nephrology: A call to action. *Int J Artif Organs* 26:447-451, 2003
7. Beathard GA, Trerotola SO, Vesely TM, et al: What is the current and future status of interventional nephrology? *Semin Dial* 18:370-379, 2005
8. Saad TF: Training, certification, and reimbursement for nephrology procedures. *Semin Nephrol* 22:276-285, 2002
9. Vesely T: Emergence of interventional nephrology as a new subspecialty. *Am J Kidney Dis* 37:876-877, 2001
10. Beathard GA, Litchfield T: Effectiveness and safety of dialysis vascular access procedures performed by interventional nephrologists. *Kidney Int* 66:1622-1632, 2004
11. Schon D, LeBlanc LM: Coding issues for the interventionalist: A consensus statement by the ASDIN. *Semin Dial* 19:525-526, 2006

PREOPERATIVE VASCULAR MAPPING

- I. Introduction: Vascular mapping before hemodialysis access creation increases the fistula placement rate and may be performed and interpreted by interventional nephrologists. Both the artery and vein need to be evaluated before vascular access placement.
 - A. The minimum diameter of the vein required for fistula placement is 2.5 mm.
 - B. The minimum diameter of the artery required for fistula placement is 2.0 mm.
- II. Preoperative vein mapping: Improves cumulative patency rates and decreases early failure rates for arteriovenous fistulae.¹ Preoperative vascular mapping may be performed by using ultrasonography or venography.
 - A. Ultrasonography is an excellent tool for vascular mapping because it is noninvasive, objective, and avoids radiocontrast exposure (Fig 1).
 - B. Although it requires minimal use of radiocontrast, venography is an alternative option to document central vein stenosis. However, it does not allow visualization of the arterial segment.

ADDITIONAL READING

1. Silva MB Jr, Hobson RW II, Pappas PJ, et al: A strategy for increasing use of autogenous hemodialysis access procedures: Impact of preoperative noninvasive evaluation. *J Vasc Surg* 27:302-307; discussion, 7-8, 1998

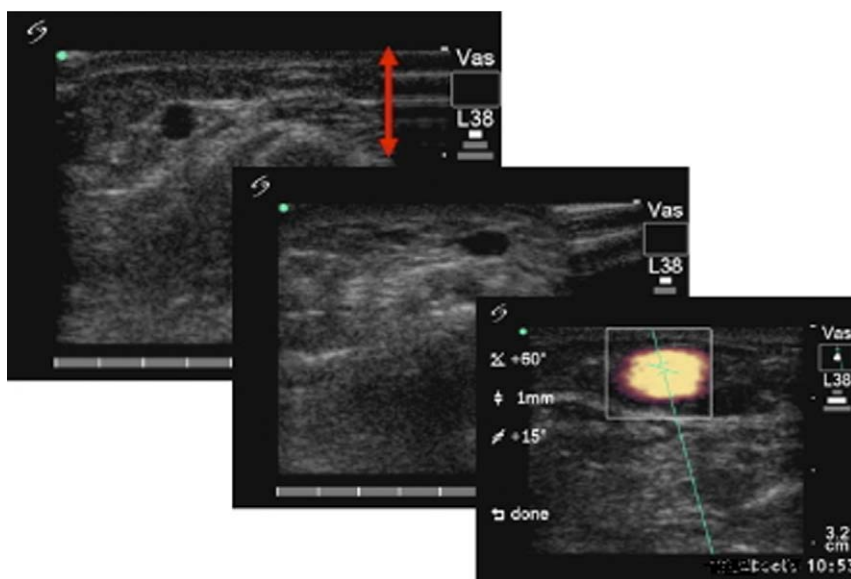


Figure 1. Vein mapping by using ultrasonography. The patient's veins are identified by using ultrasonography and measured at intervals along the entire extremity. Veins are judged adequate based on size, compressibility, and absence of sclerosis or intraluminal echoes.

2. Asif A, Ravani P, Roy-Chaudhury P, Spergel L, Besarab A: Vascular mapping techniques: Advantages and disadvantages. *J Nephrol* 20:299-303, 2007

3. Asif A, Cherla G, Merrill D, et al: Venous mapping using venography and the risk of radiocontrast-induced nephropathy. *Semin Dial* 18:239-242, 2005

4. Elsharawy MA, Moghazy KM: Impact of pre-operative venography on the planning and outcome of vascular access for hemodialysis patients. *J Vasc Access* 7:123-128, 2006

5. Allon M, Lockhart ME, Lilly RZ, et al: Effect of preoperative sonographic mapping on vascular access outcomes in hemodialysis patients. *Kidney Int* 60:2013-2020, 2001

6. Sedlacek M, Teodorescu V, Falk A, Vassalotti JA, Uribarri J: Hemodialysis access placement with preoperative noninvasive vascular mapping: Comparison between patients with and without diabetes. *Am J Kidney Dis* 38:560-564, 2001

7. Nguyen VD, Treat L, Griffith C, Robinson K: Creation of secondary AV fistulas from failed hemodialysis grafts: The role of routine vein mapping. *J Vasc Access* 8:91-96, 2007

8. Beathard GA: Strategy for maximizing the use of arteriovenous fistulae. *Semin Dial* 13:291-296, 2000

BASIC PROCEDURES FOR HEMODIALYSIS ACCESS

I. Introduction: Training in interventional nephrology requires a knowledge base sufficient for the safe, effective, and efficient application of the basic procedures encountered in interventional nephrology. Dialysis patients are unique and so are their problems. It is imperative that interventionists are well versed in the principles of dialysis and the unique problems of dialysis patients. Basic procedures, those considered standard of care for all practicing interventional nephrologists, are listed next.

A. Peripheral dialysis vascular access

B. Angiography

C. Angioplasty

D. Endovascular thrombectomy

E. Central venous access

1. Nontunneled catheter placement (short term)

2. Tunneled cuffed catheter placement (long term)

II. Description of an endovascular thrombectomy

A. Overview: In accomplishing successful thrombectomy of a vascular access, 4 steps are required:

1. Diagnostic angiogram to evaluate the graft or fistula, along with the venous outflow and central veins

2. Removal of the thrombus from the vascular access

3. Treatment of stenosis by using angioplasty

4. Dislodgement of the arterial plug to reestablish flow

B. Introduction: Although the order in which these 4 steps are performed is physician and patient dependent, all 4 steps must be performed for successful restoration of blood flow through the vascular access. Endovascular thrombectomy is performed most commonly by using thromboaspiration, which combines angiography, thrombectomy by means of thrombus aspiration, and balloon angioplasty. This procedure requires accessing the vascular access through a vascular sheath, then selecting a guidewire and embolectomy catheter. Accessing the thrombosed vascular access often is the most difficult part of the thrombectomy procedure because there usually is no blood flashback into the cannulation needle. Both the venous and arterial sides of the thrombosed access must be cannulated. It is preferable to first cannulate a straight section for insertion of the balloon catheter on the venous side of the access. The sites for cannulation should be chosen to ensure that there is enough space between the 2 vascular access sites to allow for sweeping the thrombus from the vascular lumen.

C. Initial venous cannulation: To obtain initial venous access, a graft is cannulated using an 18-G thin-walled needle in the downstream direction. A guidewire then is passed into the access, and the needle is exchanged for a 6- or 7-Fr vascular sheath. In the case of an autogenous fistula, a 21-G micropuncture needle is used first to gain access to the fistula. Ultrasound guidance may be required for cannulation. The vascular sheath facilitates aspiration of the thrombus, allows for easy introduction of the angioplasty balloon catheter or embolectomy cath-

- eter, and is used to inject radiocontrast for imaging of the access.
- D. Obtaining central venous access: The guidewire then is passed up to the level of the central veins, and a straight catheter is advanced over the guidewire to the central veins to obtain a central venous angiogram. After the central venous angiogram is obtained, any necessary drugs may be administered through this catheter, including heparin and medications used for conscious sedation.
 - E. Identifying stenotic lesions: The straight catheter is pulled back toward the introduction site to obtain an angiogram of the peripheral veins. Contrast is injected while the catheter is pulled back to delineate and identify stenotic lesions with or without thrombi.
 - F. Outflow angioplasty: An angioplasty balloon catheter of appropriate size is then advanced over the guidewire to the identified stenotic lesions or the venous anastomosis at the graft-vein interface. The angioplasty balloon is inflated with dilute radiocontrast so that it may be visualized by using fluoroscopy, until there is full balloon effacement. The entire venous side of the graft then is sequentially dilated. The angioplasty balloon is removed, leaving the wire in place to maintain access to the central circulation.
 - G. Arterial cannulation: The graft is now cannulated with the needle pointed upstream toward the arterial anastomosis at a point approximately 4 cm from the venous anastomosis. A guidewire is advanced into the access through the needle, and the needle is exchanged for another vascular sheath.
 - H. Thrombectomy: A 4-Fr embolectomy catheter next is advanced arterially through the vascular sheath. Under fluoroscopic guidance, the embolectomy catheter is pulled across the arterial anastomosis while aspirating the thrombus through the sheath side port. It may be necessary to repeat this action several times until flow is restored, indicated by a good pulse in the graft. Flow can be confirmed by injecting a small amount of radiocontrast through the side port of the venous directed sheath. If there is rapid disappearance of the contrast, a digital subtraction angiogram is obtained.
 - I. Trouble shooting: At this point, the interventionist must determine whether there is either an inflow or outflow stenosis that will require additional angioplasty. If there is evidence of an inflow stenosis, an arterial angiogram may be indicated, in which case a guidewire is advanced into the artery. A vascular catheter then is advanced over the wire, and radiocontrast is injected to visualize the artery, arterial anastomosis, and juxta-anastomotic segment. Upon recognition of an arterial stenosis, an appropriate-sized angioplasty balloon is advanced over the guidewire and inflated. In similar fashion, if a stenosis is present in the juxta-anastomotic segment, dilation using the appropriate-sized angioplasty balloon catheter is performed. In general, an angioplasty balloon catheter is oversized by about 20% for venous angioplasty. The balloon is sized according to the artery diameter for arterial angioplasty. There are no controlled studies that have examined angioplasty balloon sizing, balloon inflation pressure, or inflation duration on clinical outcomes. This is the art of angioplasty intervention, which is guided by the axiom that "veins are forgiving but arteries are not." A repeated angiogram is obtained to evaluate results of the angioplasty and identify any complications.
 - J. Recommendations: Current guidelines recommend that a greater than 50% stenosis in either the venous outflow or arterial inflow, in conjunction with clinical or physiological abnormalities, be treated by using angioplasty. The standard definition of successful angioplasty is residual stenosis less than 30% diameter reduction. This definition has no physiological or hemodynamic significance, but is the consensus opinion of the initial KDOQI working group. Several studies have shown poor correlation between degree of residual stenosis and subsequent access patency. This also is

an area for clinical outcomes investigation.

- K. Hemostasis: When satisfied that the procedure is complete, hemostasis is obtained by removing the vascular sheaths and applying manual pressure over the puncture sites. A suture may be used to temporarily close the puncture sites. The procedure is considered successful if unobstructed flow through the access is established to allow for 1 subsequent normal dialysis treatment.

- L. Outcomes: The KDOQI guidelines indicate that percutaneous transluminal angioplasty of a thrombosed vascular access should result in 40% patency at 3 months, with immediate patency of 85%. Several studies have shown better outcomes with patency greater than 60% at 6 months and assisted patency greater than 60% at 12 months. Immediate patency is more than 90%. Complications are less than 5%, generally minor in nature, and include hematomas and postprocedure bleeding. Major complications are less than 1%. Thrombosed arteriovenous fistulas were previously believed to be unsalvageable. Numerous studies have now shown that endovascular intervention is the preferred treatment. Although the procedures are technically more challenging in fistulas, results are similar to graft interventions.

III. Description of tunneled dialysis catheter placement

- A. Introduction: More than 70% of incident and 20% of prevalent long-term hemodialysis patients use a tunneled dialysis catheter. However, tunneled catheters are far from optimal as an access, with their propensity to cause central venous stenosis and their greater infection-related and all-cause mortality compared with arteriovenous fistulas and grafts.

- 1. Indications for tunneled catheter placement:
 - a) As a “bridge” until a permanent access matures
 - b) Temporary need for vascular access for dialysis

- c) As a backup when permanent access fails
- d) Patient unable to tolerate arteriovenous fistula/arteriovenous graft (severe peripheral vascular disease, low cardiac output)

2. Advantages of catheter placement:

- a) Universally applicable
- b) Ability to insert at multiple sites
- c) Maturation time not required
- d) Venipuncture not required
- e) No hemodynamic consequences
- f) Ease and low cost of placement and replacement
- g) Ability to provide access for an extended period
- h) Ease of correcting thrombotic complications

3. Disadvantages of catheter placement:

- a) High morbidity (infection, thrombosis)
- b) Risk of central venous stenosis
- c) Discomfort and cosmetic disadvantage of external appliance
- d) Shorter patency
- e) Lower blood flow rates (better with newer catheters)

- B. Overview of placement procedure: To provide general nephrologists with an overview of cuffed tunneled hemodialysis catheter placement as performed by an interventional nephrologist, the basic principles, techniques, and complications are described. It should be noted that nephrologists should establish a strategy to minimize the total catheter contact time by ensuring that the patient has a plan for a permanent access established. Cuffed catheters used for immediate access for hemodialysis can be placed safely by using conscious sedation and strict sterile technique. Dialysis is possible immediately after catheter placement.

1. Preferred location:

- a) Right internal jugular
- b) Left internal jugular
- c) Other sites based on individual patient future permanent access

2. Catheter insertion imaging techniques (imaging use is considered mandatory)

- a) Real-time ultrasound-guided insertion

- b) Fluoroscopy
- 3. Complications of cuffed tunneled catheter insertion are related almost entirely to use of the anatomic landmark technique or blind insertion
 - a) Puncture of carotid artery
 - b) Air embolism
 - c) Hemothorax
 - d) Pneumothorax
- 4. Catheter types:
 - a) Twin catheters
 - b) Step tip
 - c) Split tip
 - d) Spiral Z tip
- C. Identification of the vein: The internal jugular vein is the preferred site for insertion. The left internal jugular, despite the need to traverse 2 curves, is the second choice. However, unless the ipsilateral arm is never to be used for a permanent vascular access, a catheter should never be placed in the subclavian vein. Placement of a cuffed tunneled catheter requires a maximum barrier protection environment. Before surgical scrub, it is helpful to examine the selected site by using ultrasound to ensure that the patient has a suitable vein. The vein is identified easily by using ultrasound because it typically collapses with gentle pressure of the probe.
- D. Initial venous cannulation: The site for insertion is infiltrated with local anesthesia. Real-time ultrasound-guided puncture using a 21-G micropuncture needle and fluoroscopy guidance are requirements for safe and effective insertion. A 21-G micropuncture needle with an attached syringe is inserted into the vein. The small needle limits potential complications. This syringe is removed, then a 0.018-inch guidewire is inserted through the needle. The guidewire is advanced and the position of the guidewire is confirmed by using fluoroscopy. The needle is removed and a 5-Fr coaxial dilator is inserted over the guidewire. The guidewire and 3-Fr intertranslational dilator are removed, leaving the 5-Fr outer dilator in place. A flow switch or stopcock is attached to the dilator for hemostasis. Having achieved central venous access, conscious sedation can be administered as appropriate.
- E. Creation of a subcutaneous tunnel: A subcutaneous tunnel can be created before or after guidewire placement. Tunneling before placement of the guidewire minimizes the amount of time a guidewire is in the circulation and ensures immediate access to the central circulation. A 1-cm incision is made lateral to the insertion site. The subcutaneous tissue is exposed by blunt dissection around the 5-Fr dilator. This ensures that the catheter bend will be kink free with no skin tags. The catheter exit site on the patient's chest is located according to the patient's body habitus and type of catheter that will be used. When the exit site for the catheter is chosen, the area is infiltrated with local anesthesia, and a puncture is made through the skin by using a knife blade. A no. 11 blade inserted parallel through the skin at the exit site usually is ideal. A long needle then can be used to infiltrate the tunnel tract extending from the exit site to the insertion site with local anesthesia. The appropriate-sized catheter is mounted on the end of the tunneling device. The tunneling device with the catheter attached then is passed from the exit site subcutaneously to the insertion site for an antegrade tunneled catheter. The cuff of the catheter is pulled into the tunnel, and the tunneling device is removed from the catheter.
- F. Dilatation of the venotomy: Attention is now turned toward dilation of the soft tissue tract and venotomy for insertion of a catheter into the central vein. A guidewire next is passed through the 5-Fr dilator into the inferior vena cava under fluoroscopic guidance. Placement of the guidewire into the inferior vena cava decreases the likelihood of cardiac arrhythmias. It may be necessary to use a directional guidewire, such as an angled guidewire with a guiding catheter, such as a Kumpe catheter, to assist in placement of the guidewire into the inferior vena cava. The 5-Fr dilator is removed, and in a stepwise fashion, serial dilators of increasing size are passed to dilate the soft tissue and venous tract. Care is taken so that the dilator moves freely over the guidewire's long axis to avoid perforating the vein or mediastinum. A fluoroscope should be used

to verify proper positioning if there is doubt about the location of the dilator or resistance or difficulty dilating the tract. The final dilator with peel-way sheath then is inserted over the guidewire. The dilator is removed, leaving the peel-away sheath and guidewire in place. It is important to leave the guidewire in place to ensure that access to the central circulation is available. When the dilator is removed, the peel-away sheath is introduced to prevent bleeding and possible air embolism.

- G. Catheter placement: The catheter is inserted over the guidewire and advanced maximally, the sheath is split and peeled down to the level of the insertion site, and the catheter then is advanced farther. This ensures that the sheath is peeled outside the venotomy. When the sheath has been completely removed, the catheter is pulled back into the tunnel with the cuff approximately 1 to 2 cm from the exit site. Alternatively, the catheter may be advanced over the guidewire by using a sheathless technique. This method uses serial dilatations instead and is believed to reduce the risk of air embolism.
- H. Optimizing catheter placement: The 3T test is performed: tip, top, and tug. Using fluoroscopy, proper placement of the catheter tip is verified. The top is checked to ensure that the catheter makes a smooth curve without kinks that will restrict flow. Finally, the tug test involves rapidly withdrawing blood with a syringe to ensure adequate blood flow without hesitation. If any problems are identified, they should be corrected before the patient leaves the procedure room. The exit site is closed using a pursestring suture, and additional sutures may be used to hold the catheter at the hub. Each catheter lumen then is filled with the appropriate amount of locking solution, and a nonocclusive sterile dressing is applied over the insertion.
- I. Catheter dysfunction: KDOQI defines catheter dysfunction as failure to attain and maintain extracorporeal blood flow greater than 300 mL/min with pre-pump arterial pressure more negative than -250 mm Hg.
 1. Early flow problems usually are a result of faulty placement
 - a) Tip malposition

- b) Kinked catheter
 2. Late flow problems
 - a) Extrinsic mural or atrial thrombus
 - b) Intrinsic thrombus or fibrin sheath
 3. Treatment of catheter dysfunction
 - a) Forceful saline flush
 - b) Thrombolytics
 - c) Mechanical therapy (endoluminal brush)
 - d) Replacement of catheter
 - e) Fibrin sheath stripping
 - J. Catheter-related infection:
 1. Exit-site infection: local care
 2. Tunnel infection: catheter exchange with new tunnel
 3. Catheter-related bacteremia: antibiotics with catheter exchange, with or without a new exit site/tunnel
- IV. Knowledge base
- A. Didactics: At a minimum, a period of didactic training is essential to address the following topics:
 1. Basic anatomy related to hemodialysis vascular access
 2. Physical examination of the vascular access
 3. Surveillance techniques and monitoring for venous stenosis
 4. Basic tools and procedures of interventional nephrology
 5. Radiation safety, imaging equipment, and imaging techniques
 6. Sedation and analgesia
 7. Angioplasty of dialysis vascular access, peripheral draining veins, and central veins
 8. Thrombolysis and/or thrombectomy of dialysis vascular access
 9. Hemodialysis catheters
 10. Types of catheters, uses, advantages, and disadvantages
 11. Techniques related to placement and management of catheters
 12. Central vein stenosis
 - B. Hands-on training: At a minimum, training in interventional nephrology must include a period of active hands-on training sufficient to provide clinical competence in the basic procedures listed. Certification of a nephrologist as an interventional nephrologist is based on training, experience, and

demonstrated clinical expertise (Table 1). Certification shall require that applicants demonstrate their clinical expertise by submitting records documenting their ability to diagnose problems, individualize treatment, perform procedures, and recognize and manage complications appropriately. It cannot be emphasized enough that the key word here is primary operator, with the trainee performing the procedure with no intervention from the supervising physician.

1. Angiography: As the primary operator, the trainee must satisfactorily perform complete angiographic procedures designed to study peripheral hemodialysis vascular access in 25 patients under the supervision of a qualified interventionist. This should include both arteriovenous grafts and autogenous fistulas.
2. Angioplasty: As the primary operator, the trainee must satisfactorily perform angioplasty procedures on the hemodialysis vascular access in 25 patients under the supervision of a qualified interventionist. This should include both arteriovenous grafts and autogenous fistulas.
3. Thrombolysis/thrombectomy: As the primary operator, the trainee must satisfactorily perform thrombolysis/thrombectomy procedures on the hemodialysis vascular access in 25 patients under the supervision of a qualified interventionist. This should include both arteriovenous grafts and autogenous fistulas.

4. Nontunneled short-term hemodialysis catheters: As the primary operator, the trainee must satisfactorily place nontunneled short-term hemodialysis catheters in 25 patients. This requirement may have been met as part of a trainee's primary nephrology training. In this case, appropriate documentation of experience is required.
5. Tunneled cuffed long-term hemodialysis catheters: As the primary operator, the trainee must satisfactorily place tunneled cuffed long-term hemodialysis catheters in 10 patients under the supervision of a qualified interventionist.

ADDITIONAL READING

1. Lok CE: Fistula first initiative: Advantages and pitfalls. *Clin J Am Soc Nephrol* 2:1043-1053, 2007
2. Spergel LM: Has the Fistula First Breakthrough Initiative caused an increase in catheter prevalence? *Semin Dial* 21:550-552, 2008
3. Tessitore N, Mansueto G, Lipari G, et al: Endovascular versus surgical preemptive repair of forearm arteriovenous fistula juxta-anastomotic stenosis: Analysis of data collected prospectively from 1999 to 2004. *Clin J Am Soc Nephrol* 1:448-454, 2006
4. Nassar GM, Nguyen B, Rhee E, Achkar K: Endovascular treatment of the "failing to mature" arteriovenous fistula. *Clin J Am Soc Nephrol* 1:275-280, 2006
5. Falk A: Maintenance and salvage of arteriovenous fistulas. *J Vasc Interv Radiol* 17:807-813, 2006
6. Schon D, Blume SW, Niebauer K, Hollenbeak CS, de Lissoyoy G: Increasing the use of arteriovenous fistula in hemodialysis: Economic benefits and economic barriers. *Clin J Am Soc Nephrol* 2:268-276, 2007
7. Maya ID, Allon M: Outcomes of thrombosed arteriovenous grafts: Comparison of stents vs angioplasty. *Kidney Int* 69:934-937, 2006
8. Roy-Chaudhury P, Kelly BS, Miller MA, et al: Venous neointimal hyperplasia in polytetrafluoroethylene dialysis grafts. *Kidney Int* 59:2325-2334, 2001
9. Li L, Terry CM, Shiu YT, Cheung AK: Neointimal hyperplasia associated with synthetic hemodialysis grafts. *Kidney Int* 74:1247-1261, 2008
10. Maya ID, Oser R, Saddekni S, Barker J, Allon M: Vascular access stenosis: Comparison of arteriovenous grafts and fistulas. *Am J Kidney Dis* 44:859-865, 2004
11. Ash SR: Fluid mechanics and clinical success of central venous catheters for dialysis—Answers to simple but persisting problems. *Semin Dial* 20:237-256, 2007
12. Janne d'Othee B, Tham JC, Sheiman RG: Restoration of patency in failing tunneled hemodialysis catheters: A comparison of catheter exchange, exchange and balloon disruption of the fibrin sheath, and femoral stripping. *J Vasc Interv Radiol* 17:1011-1015, 2006

Table 1. Certification Requirements for Basic Hemodialysis Procedures

Procedure	No. of Cases (as primary operator)
AVG/AVF: Angiography	25
AVG/AVF: Angioplasty	25
AVG/AVF: Thrombectomy	25
Nontunneled catheter placement	25
Tunneled catheter placement	10

Abbreviations: AVF, arteriovenous fistula; AVG, arteriovenous graft.

13. Work J: Chronic catheter placement. *Semin Dial* 14:436-440, 2001

14. Vesely TM, Beathard G, Ash S, Hoggard J, Schon D, ASDIN Clinical Practice Committee: Classification of complications associated with hemodialysis vascular access procedures. A position statement from the American Society of Diagnostic and Interventional Nephrology. *J Vasc Access* 9:12-19, 2008

15. Beathard GA: Management of complications of endovascular dialysis access procedures. *Semin Dial* 16:309-313, 2003

16. Schwab SJ, Beathard G: The hemodialysis conundrum: hate living with them, but can't live without them. *Kidney Int* 56:1-17, 1999

ADVANCED PROCEDURES FOR HEMODIALYSIS ACCESS

I. Definition: Advanced procedures are those that may be encountered with vascular access problems, but are more complex than the basic procedures. They include endovascular stent placement, accessory vein obliteration, and subcutaneous port placement. The complexity of these procedures, as well as their possible complications, requires highly developed skills, including manipulation of the guidewires, selective catheterization, embolization, and ligation of vessels. The precise role of these procedures in the endovascular management of dialysis access problems has not yet been fully delineated.

II. Knowledge base: If a nephrologist desires to perform the advanced procedures encountered in interventional nephrology, he or she must have first completed training in the basic procedures of interventional nephrology and possess a knowledge base sufficient for the safe, effective, and efficient application of these procedures. At a minimum, a period of didactic training is essential to address the following topics:

A. Endovascular stent placement: The role of endoluminal stents has not been fully delineated in the interventional management of dialysis access. In the United States, stents are not approved by the Food and Drug Administration for use in dialysis access, and their use is justified only if there are clear indications that they will either extend the life of the access or save an otherwise failed access

and avoid surgery. In addition, a stent adds considerably to the cost of the procedure and has the potential to promote the development of neointimal hyperplasia and deplete the vein that may be used for future revisions, as well as migrate into the circulation. At present, the indications for stent placement are few.

1. Indications for stent placement:

- a) Vein rupture: Vascular injury at the site of angioplasty may result in extravasation of contrast or a hematoma. Management depends on its effect on flow and its size. The first option would be to gently reinflate the angioplasty balloon across the site; however, if this is unsuccessful, a stent may be placed.
- b) Elastic lesion: An elastic lesion is one that dilates completely with the angioplasty balloon, but after dilatation still has significant ($\geq 50\%$) residual stenosis, showing elastic recoil. Due consideration should be given to surgical revision; however, if the lesion is not surgically accessible, a stent may be placed.

2. Contraindications for stent placement:

- a) Surgically accessible venous stenosis
- b) Infected access
- c) Undersized stent (potential for migration)
- d) Cannulation sites (although a covered stent may be used)
- e) Placement at bends and curves
- f) Placement at the confluence of 2 vessels

3. Stent construction and types: Self-expanding stents commonly are used for dialysis access. They are intentionally oversized at the time of placement and continue to expand after placement. A majority of stents available are made of nitinol, a metal alloy that is elastic and has "thermal shape memory." Heating to more than a certain temperature allows the stent to regain its original shape and strength. The elasticity allows it to be introduced into the body through relatively small delivery systems. When de-

ployed inside the body, it expands to its original shape as a result of the thermal effect.

4. Access patency after stent placement: Stents may promote neointimal hyperplasia, and primary patency rates average 20% at the end of 1 year. However, with the use of adjunct devices, cumulative patency may be increased to 70% at the end of 1 year. In view of the limited patency rates and depletion of a section of the vein that eventually may be needed for a surgical revision, the authors recommend judicious use of stent placement, and angioplasty should be used as the primary treatment for all venous lesions.
- B. Accessory vein (fistula side-branch) obliteration: Accessory vein obliteration may be used to salvage immature arteriovenous fistulas. The decision to obliterate an accessory vein is based on its significance, evidenced by its size and the amount of flow through it. In addition, if the arteriovenous fistula augments on occlusion of the accessory vein, it may be helpful in making the diagnosis. However, any downstream lesion should be treated before obliterating an accessory vein because these can be functional and may disappear after successful resolution of downstream stenosis. There are 3 ways to obliterate accessory veins: percutaneous ligation, surgical cutdown and vein isolation, and coil placement and obliteration.
1. Percutaneous ligation: This should be attempted only if the vein is visible or palpable. The fistula should be cannulated below the most distal accessory vein, and an angiogram should be obtained. The accessory vein then should be marked on the skin surface with a sterile marker. The area over the accessory vein should be anesthetized, and a suture should be placed through the skin to encircle the vein. However, a repeated angiogram needs to be obtained to confirm obliteration of the accessory vein before tightening the suture, which may be removed after 10 days.
 2. Surgical cutdown and vein isolation: The fistula should be cannulated below the most distal accessory vein, and an angiogram should be obtained. The accessory vein then should be marked on the skin surface with a sterile marker. The area over the accessory vein should be anesthetized, and a small incision is made over the skin. Blunt dissection is used to expose the accessory vein, which then is ligated with a suture placed through the skin to encircle the vein. A repeated angiogram should be obtained to confirm obliteration of the accessory vein before tightening the suture.
 3. Coil placement and obliteration: The fistula should be cannulated below the most distal accessory vein and an angiogram should be obtained using a micropuncture set. This then can be exchanged into a 6-Fr sheath. A guidewire is placed into the accessory vein and a guiding catheter is advanced over it. When the catheter tip position is confirmed within the accessory vein (by injecting a small amount of contrast), the coil is loaded into the catheter and deployed. The coil should be sized to the vein that is being obliterated to minimize complications. A repeated angiogram should be obtained to confirm obliteration of the accessory vein.
- C. Subcutaneous port placement: Subcutaneous ports, such the LifeSite Hemodialysis System (Vasca, Inc, Tewksbury, MA), incorporate 2 silicone catheters positioned in the central venous system and connected to a stainless steel-titanium valve implanted in a subcutaneous pocket. They were believed to have a lower theoretical incidence of infections compared with tunneled catheters because the skin barrier remains intact. Initial results were promising; however, these were not borne out by subsequent evaluations, and the device was withdrawn from the market. At present, there currently are no Food and Drug Administration–approved subcutaneous ports avail-

able for hemodialysis use in the United States.

- III. Hands-on training: At a minimum, training in advanced procedures in interventional nephrology must include a period of active hands-on training sufficient to provide clinical competence in the basic procedures listed above. As the primary operator, the trainee must satisfactorily perform:
 - A. Endovascular stent placement in 5 patients under the supervision of a qualified interventionist
 - B. Accessory vein obliteration in 5 patients under the supervision of a qualified interventionist
 - C. Subcutaneous port placement in 5 patients under the supervision of a qualified interventionist

PLACEMENT OF PERMANENT PERITONEAL DIALYSIS CATHETERS

- I. Overview: Placement of permanent peritoneal dialysis (PD) catheters by interventional nephrologists should be encouraged. The goal of peritoneal access is to provide a stable interface between the catheter and the body, have minimal interference with abdominal function and clothing, and remain maintenance free and infection free. Ideally, catheter design should include the largest practical internal diameter to provide maximum flow, allow leak resistance, be constructed of a biocompatible material, and allow for easy implantation and removal. Catheter materials include silicone and polyurethane. Silicone is used most frequently because of its superior biocompatibility and no leachable plasticizers. However, polyurethane allows thinner walled catheters, providing a larger lumen and greater flow rates. Polyurethane may crack or blister when exposed to alcohol or alcohol-based ointments. Newer formulations of polyurethane are now resistant to alcohol. Similar to hemodialysis access catheters, peritoneal catheters with either silver or antibiotic coatings have not proved efficacious. Several studies have confirmed the advantage of using a curved subcutaneous tunnel with a downward-directed exit site to reduce infec-

tions. The lateral or paramedian insertion site is the preferred site based on lower catheter-related peritonitis rates. This location has fewer vascular structures and is located in proximity to the rectus muscle. The internal cuff is placed within the rectus muscle and the external cuff in the subcutaneous tissue of the anterior abdominal wall. The function of the cuff is to induce an inflammatory reaction that stimulates in-growth of fibrous tissue. In a similar fashion, the external cuff at the skin exit site stimulates granulation tissue, creating a barrier to bacteria entering the subcutaneous space from the skin surface. Using these general approaches, PD catheter survival rates are greater than 80% at 1 year and greater than 70% at 2 years. There are 4 techniques, provided next, for the placement of permanent PD catheters. Details of these procedures have been adequately covered in a previous Core Curriculum in the *American Journal of Kidney Diseases* from Teitelbaum and Burkart (November 2003; freely available at www.ajkd.org). Certification of an interventionist in performing procedures related to PD catheters must be based on documentation of training, experience, and clinical expertise in 1 or more of these techniques.

- A. Seldinger technique (placement involving a needle, guidewire, dilator, and split sheath)
 - B. Surgical technique (by dissection)
 - C. Peritoneoscopic technique (using a peritoneoscope to inspect the abdomen and a spiral guide to advance the catheter into the abdomen)
 - D. Laproscopic technique (patients with multiple previous surgeries are referred to surgery for laparoscopic placement of the PD catheter).
- II. Description of PD catheter placement
 - A. Introduction: To provide general nephrologists an overview of PD catheter placement as performed by an interventional nephrologist, the basic principles, techniques, and complications of the percutaneous approach with fluoroscopic guidance using the Seldinger technique are described.

- B. Initial access: The PD catheter generally is placed on the left side. Using both conscious sedation and local lidocaine, a 5-cm incision is made 1 to 2 cm below and 2 to 3 cm lateral to the umbilicus. Using blunt dissection, the rectus sheath is exposed. Although this entry point usually avoids the epigastric artery, an ultrasound probe may be used to document its location. A 22-G needle from a micropuncture set is inserted with the needle directed toward the lower pelvis. Verification that the needle is within the peritoneal cavity is confirmed by injecting a small amount of contrast. If the needle is within the peritoneal cavity, a typical bowel pattern should be observed under fluoroscopy. The micropuncture wire then is inserted through the needle under fluoroscopic guidance to confirm its position in the lower pelvis. The needle is exchanged for a 5-Fr dilator, and a 0.035 guidewire then is advanced through the dilator into the lower pelvis.
- C. Catheter placement: The opening into the peritoneal cavity is enlarged by using serial dilators over the guidewire until a final 18-Fr dilator with a peel-away sheath is advanced over the wire (Cook-Medical Inc, Bloomington, IN). The PD catheter is advanced over the guidewire into its final location and the internal cuff is buried in the rectus muscle. Approximately 500 mL of dialysate is infused rapidly through the catheter, and its outflow is assessed to confirm adequate function. The urinary bag is checked and the clarity of the dialysate is noted to ensure no complications.
- D. Subcutaneous tunnel: A subcutaneous tunnel for the PD catheter is created to the exit. Specifically, the external cuff should be located 1 to 2 cm within the tunnel from the exit site, and the exit site, created by using a no. 11 scalpel, should allow for a tight fit around the catheter and not require sutures. The surgical incision is closed in layers. The catheter is flushed with heparinized saline after the appropriate connectors have been attached.
- E. Postoperative care: Postoperative care includes securely capping the catheter, cov-

ering the incision with sterile gauze and not using bio-occlusive dressings, and keeping the site dry. The catheter usually is not used until 3 to 4 weeks after implantation before full fluid exchanges of 2 to 3 L are started. During this waiting period, depending on PD unit policy, the catheter may be accessed once a week, during which small volume exchanges of 500 mL are performed. In case of an immediate need for dialysis, PD exchanges may be started by using smaller exchange volumes, therefore avoiding a central venous catheter.

III. Knowledge base

- A. Didactics
 1. Basic anatomy related to PD access
 2. Procedures and techniques of peritoneal catheter placements
 3. Complications of catheter placements
 4. Sedation and analgesia
- B. Hands-on training: At a minimum, training in procedures related to PD catheter placement must include a period of active hands-on training sufficient to provide clinical competence in 1 or more of the techniques listed. As the primary operator, the trainee must satisfactorily perform permanent PD catheter placement in 6 patients under the supervision of a qualified interventionist.

ADDITIONAL READING

1. Gadallah MF, Pervez A, el-Shahawy MA, et al: Peritoneoscopic versus surgical placement of peritoneal dialysis catheters: A prospective randomized study on outcome. *Am J Kidney Dis* 33:118-122, 1999
2. Asif A, Byers P, Vieira CF, et al: Peritoneoscopic placement of peritoneal dialysis catheter and bowel perforation: Experience of an interventional nephrology program. *Am J Kidney Dis* 42:1270-1274, 2003
3. Ash S: Guidelines for training, certification, and accreditation in placement of permanent tunneled and cuffed peritoneal dialysis catheters. *Semin Dial* 15:440-442, 2002
4. Ash SR: Chronic peritoneal dialysis catheters: Overview of design, placement, and removal procedures. *Semin Dial* 16:323-334, 2003
5. Zaman F, Pervez A, Atray NK, Murphy S, Work J, Abreo KD: Fluoroscopy-assisted placement of peritoneal dialysis catheters by nephrologists. *Semin Dial* 18:247-251, 2005
6. Rosenthal MA, Yang PS, Liu IL, et al: Comparison of outcomes of peritoneal dialysis catheters placed by the fluoro-

scopically guided percutaneous method versus directly visualized surgical method. *J Vasc Interv Radiol* 19:1202-1207, 2008

7. Maio R, Figueiredo N, Costa P: Laparoscopic placement of Tenckhoff catheters for peritoneal dialysis: A safe, effective, and reproducible procedure. *Perit Dial Int* 28:170-173, 2008

8. Gajjar AH, Rhoden DH, Kathuria P, Kaul R, Udupa AD, Jennings WC: Peritoneal dialysis catheters: Laparoscopic versus traditional placement techniques and outcomes. *Am J Surg* 194:872-875; discussion, 5-6, 2007

9. Maya ID: Ultrasound/fluoroscopy-assisted placement of peritoneal dialysis catheters. *Semin Dial* 20:611-615, 2007

10. Schmidt SC, Pohle C, Langrehr JM, Schumacher G, Jacob D, Neuhaus P: Laparoscopic-assisted placement of peritoneal dialysis catheters: Implantation technique and results. *J Laparoendosc Adv Surg Tech A* 17:596-599, 2007

11. Teitelbaum I, Burkart J: Peritoneal dialysis. *Am J Kidney Dis* 42:1082-1096, 2003

RECERTIFICATION

I. Overview: To maintain their status with the ASDIN, interventional nephrologists must be recertified every 5 years. Recertification of an interventional nephrologist will be based on continued documentation of both clinical expertise and continuing activity in the field.

A. Clinical expertise: Applicants must demonstrate their continuing clinical expertise by submitting records documenting their ability to diagnose problems, individualize treatment, perform procedures, and recognize and manage complications appropriately (Table 2).

B. Continuing activity: Applicants must demonstrate their continuing activity in interventional nephrology by submitting documentation as listed in Table 2 that they have performed the

following minimum number of interventions during each of the past 5 years.

ACCREDITATION OF INTERVENTIONAL NEPHROLOGY TRAINING PROGRAMS

I. Overview: Training programs will be responsible for training new nephrology fellows in interventional nephrology and can provide training resources for nephrologists who are already in practice. Therefore, it is essential that these programs meet specific requirements to ensure that their graduates will be able to fulfill the training requirements outlined here.

II. Funding: The training program must show evidence that a continuing source of funding sufficient to support the program exists.

III. Faculty: A faculty that is committed to the program will be required. Minimal basic requirements shall be:

A. At least 1 full-time faculty member who meets the certification requirements of the ASDIN

B. At least 1 faculty equivalent dedicated full time to the interventional training facility

IV. Facility: For a training program in interventional nephrology to be successful, it must be associated with a full-time interventional facility that is specifically designed, equipped, supplied, and staffed to manage the problems associated with hemodialysis vascular access. This shall require the following as minimum:

A. Space: An adequate interventional facility for hemodialysis vascular access requires that adequate space be allotted for:

1. Patient waiting area
2. Patient dressing area
3. Preoperative evaluation/recovery area
4. Procedure room
5. Supply/storage area

B. Equipment: Proper equipment for the safe, effective, and efficient accomplishment of the procedures performed is essential. The following minimum is required:

1. Patient monitoring equipment
2. Fluoroscopy equipped for vascular procedures
3. Equipment for making permanent records of images for documentation

Table 2. Annual Continuing Activity Requirements for Basic Hemodialysis Procedures

Procedure	No. of Cases
AVG: Angiography	25
AVG: Angioplasty	25
AVG: Thrombectomy	25
AVF: Angiography	5
AVF: Angioplasty	5
AVF: Thrombectomy	2
Tunneled catheter placement	25

Note: A combined procedure will provide a case in more than 1 category.

Abbreviations: AVF, arteriovenous fistula; AVG, arteriovenous graft.

Table 3. Minimal Requirements for Accreditation of Interventional Nephrology Training Programs

Procedure	No. of Cases
AVG/AVF: Angiography	300
AVG/AVF: Angioplasty	300
AVG/AVF: Thrombectomy	100
Tunneled catheter placement	100

Abbreviations: AVF, arteriovenous fistula; AVG, arteriovenous graft.

4. Procedure table suitable for fluoroscopy imaging
 5. Adequate lighting
 6. Ultrasound equipment suitable for catheter placements
- C. Supplies: Proper supplies for the full range of interventional procedures performed in the facility must be available. Mechanisms for the reordering of supplies must be established. Adequate storage for supplies must be provided.
- D. Staff: To perform interventional procedures, adequately trained dedicated staff must be provided so that the procedure can be performed safely, effectively, and efficiently. The following minimal number of staff is required:
1. Advanced Cardiac Life Support–certified nurse to monitor the patient during the procedure
 2. Scrub technician to assist the operator in performing the procedure
 3. Technician to manage the radiographic equipment during the procedure (certified radiology technician is recommended)
- E. Volume of procedures: For a training program to be successful, it should be actively performing interventional procedures on an ongoing basis. The minimum annual procedures required to attain and maintain accreditation are listed in Table 3.

- F. Procedure records: Reports of the procedures performed must be generated and placed in the patient's permanent medical record. Documentation of all procedures is a necessity. Each trainee should receive documentation of the types of procedures performed, the number of each type of procedure performed, and the outcome of the procedure. Maintaining a computerized database is strongly recommended.
- G. Quality assurance: An ongoing quality assurance program is an essential part of any interventional facility. The purpose of this program should be to provide for a systematic method to continuously assess and improve all aspects of health care delivery. It should be designed to improve patient care outcomes through the ongoing objective assessment of important aspects of patient care based on quality, cost, and service and the appropriate solutions of identified problems. Medical necessity, appropriateness of care, and adverse outcomes should be monitored. Practice guidelines should be developed and monitored. Outcome data should be collected and analyzed on an ongoing basis.
1. Site visit: Accreditation will require a site visit after these criteria are met, but not before 6 months after initiation of the program.
 2. Accreditation interval: For the program to maintain its status with the ASDIN, it must be accredited every 3 years. The Accreditation Committee of the ASDIN will determine the process by which this is accomplished.

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