

III. NKF-K/DOQI CLINICAL PRACTICE GUIDELINES FOR VASCULAR ACCESS: UPDATE 2000

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Acronyms and Abbreviations

Abbreviation	Term
A	arterial
ASA	acetylsalicylic acid
AV	arteriovenous
BFR	blood flow rate
BUN	blood urea nitrogen
CDC	Centers for Disease Control
CKD	chronic kidney disease
CQI	continuous quality improvement
DOQI	Dialysis Outcomes Quality Initiative
ESRD	end-stage renal disease
IV	intravenous
NCDS	National Cooperative Dialysis Study
NKF	National Kidney Foundation
PTA	percutaneous transluminal angioplasty
PTFE	polytetrafluoroethylene
QA	quality assurance
R	recirculation
S	sample
t	time
URR	urea reduction ratio
USRDS	United States Renal Data System
V	volume of distribution (when referring to urea, V = total body water)
V	venous
VA	vascular access

Introduction

ADEQUATE CARE OF an end-stage renal disease (ESRD) hemodialysis dependent patient requires constant attention to the need to maintain vascular access patency. An ideal access delivers a flow rate adequate for the dialysis prescription, has a long use-life, and has a low rate of complications (eg, infection, stenosis, thrombosis, aneurysm, and limb ischemia). Although no current access type fulfills all of these criteria, the native arteriovenous (AV) fistula comes the closest to doing so. Studies demonstrate that native accesses have the best 4 to 5 year patency rates and require the fewest interventions compared to other access types.^{3,4} Yet, in the United States, the growth of the ESRD hemodialysis program has been accompanied by a decreased use of native AV fistulae and an increased use of synthetic AV grafts and silastic cuffed central catheters for permanent hemodialysis access.^{5,6} The United States Renal Data System (USRDS) recently reported that insertion of polytetrafluoroethylene (PTFE) grafts occurred almost twice as often as construction of native accesses in the 1990 incident cohort of patients.⁶ Significant geographic variation in the ratio of native fistula construction to graft placement has also been noted.

The substitution of synthetic grafts for native fistulae has increased patient care costs in part due to the increased number of procedures needed to maintain patency of grafts compared to native fistulae.⁷ In addition, late referral of patients for permanent access placement is reflected in patient hospitalizations. In some regions, up to 73% of patients are hospitalized for initiation of hemodialysis, almost invariably for temporary dialysis catheter access.⁸ Early referral of chronic kidney failure patients to a nephrologist allows for access planning and thus increases the probability of AV fistula formation.

As a result of current practice patterns, hemodialysis access failure is a major cause of morbidity for patients on hemodialysis. Various reports indicate that a high percentage of ESRD patient hospitalizations are due to vascular access complications.^{6,9-11} The USRDS reports that hemodialysis access failure is the most frequent cause of hospitalization among

ESRD patients, and in some centers it accounts for the largest number of hospital days.¹² Reports also indicate a decreasing interval between placement of a vascular access and a surgical procedure needed to restore patency,^{7,10} with significant costs to restore patency.^{6,12} It has been demonstrated that an aggressive policy for monitoring AV graft patency extends graft life and minimizes graft thrombosis (see Guideline 10: Monitoring Dialysis AV Grafts for Stenosis). Thus, much access-related morbidity and associated costs are avoidable. The number of interventions required to maintain access patency may be reduced further by the use of native fistulae rather than AV grafts.

After evaluating all of the available data on vascular access, the Vascular Access Work Group concluded that quality of life and overall outcomes for hemodialysis patients could be improved significantly by achieving two primary goals:

1. Increasing the placement of native AV fistulae.
2. Detecting access dysfunction prior to access thrombosis.

The available data argue strongly that such an approach should enhance long-term access function and reduce the costs associated with the maintenance of access patency. To achieve these objectives, the Work Group has developed this set of practice guidelines as well as strategies for implementation. At the core of these guidelines is the goal of early identification of patients with progressive kidney disease and the identification and protection of potential native fistula construction sites—particularly sites using the cephalic vein—by members of the healthcare team and patients.

Once access has been constructed, dialysis centers need to employ a multifaceted quality assurance (QA) program to detect vascular accesses at risk, track access complication rates, and implement procedures that maximize access longevity. The Work Group has developed explicit guidelines regarding which tests to use to

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evaluate a given access type and when and how to intervene to reduce thrombosis and underdialysis. The Work Group believes that the guidelines are reasonable, appropriate, and achievable. Attainment of these goals will require the concerted efforts of not only practicing nephrologists, but also nephrology nurses, access surgeons, vascular interventionalists, patients, and other members of the healthcare team.

Evidence-Based Versus Opinion-Based Guidelines

To the greatest extent possible, these guidelines are based on evidence in the published literature. Where evidence is not available, the guidelines are based on the opinion of the Work Group. For each guideline, there is a clear indication of whether the guideline is based on evidence, opinion, or both.

I. Patient Evaluation Prior to Access Placement

GUIDELINE 1

Patient History and Physical Examination Prior to Permanent Access Selection

To determine the type of access most suitable for an ESRD patient, a history must be taken and physical examination of the patient's venous, arterial, and cardiopulmonary systems must be performed. Diagnostic evaluation should be performed when indicated based on patient history or physical examination. (*Evidence/Opinion*)

Table III-1 outlines relevant aspects of patient history and physical examination and provides the rationale for evaluating them.

Rationale Characteristics of the patient's arterial, venous, and cardiopulmonary systems will influence which access type and location are most desirable for the patient.¹³⁻¹⁹ The patient's life expectancy and planned duration of ESRD therapy also can influence the type and location of the access.

GUIDELINE 2

Diagnostic Evaluation Prior to Permanent Access Selection

- A. Venography prior to placement of access is indicated in patients with the following:
 1. Edema in the extremity in which an access site is planned (**Evidence**)
 2. Collateral vein development in any planned access site (**Evidence**)
 3. Differential extremity size, if that extremity is contemplated as an access site (**Evidence**)
 4. Current or previous subclavian catheter placement of any type in venous drainage of planned access (**Evidence**)
 5. Current or previous transvenous pacemaker in venous drainage of planned access (**Evidence**)
 6. Previous arm, neck, or chest trauma or surgery in venous drainage of planned access (**Opinion**)
 7. Multiple previous accesses in an extremity planned as an access site (**Opinion**)
- B. Additional or alternate imaging techniques are indicated in selected cases where multiple previous vascular accesses have been placed or when residual kidney function

makes contrast studies undesirable. Appropriate techniques include:

1. Doppler ultrasound (**Evidence**)
2. Magnetic Resonance Imaging (**Opinion**)

- C. Arteriography or Doppler examination is indicated when arterial pulses in the desired access location are markedly diminished (**Opinion**)

Rationale Venography allows identification of veins suitable for attempted access creation and can be used to exclude sites no longer suitable for access creation. Each of the conditions listed above is associated with vein impairment; each may render a site unsuitable for creating access. Specific factors are as follows:

Extremity edema, collateral vein development, or differential extremity size may indicate inadequate venous drainage or central vein obstruction.^{14,15,20-22} Detection of the underlying anatomical defect(s) should be attempted by venography. Such defects should be corrected prior to access placement; the site should not be used for access creation if the anatomical defect(s) cannot be detected and corrected.

Subclavian vein cannulation and transvenous pacemaker placement are associated with central vein stenosis and thrombosis.^{17,20,23-28} Thus, access should never be placed on the same side as an existing transvenous pacemaker or an existing subclavian catheter unless other options have been exhausted. An extremity should not be used for access creation if catheter-induced central vein stenosis or thrombosis on the same side cannot be corrected.

Arm, neck, and chest surgery and trauma are associated with central vein stenosis and obliteration of central veins. Thus, a history of these findings may affect access site choice. Multiple previous access placements may likewise limit availability of veins suitable for access placement.^{18,19}

Doppler studies may be used in lieu of venography at facilities where this modality is available and reliable for venous assessment.²⁹⁻³⁵ However, this method is less accurate than venography for evaluation of central vein structures.³³ Doppler studies or magnetic resonance imaging may be preferred to venography and arteriography in

Table III-1. Patient Evaluation Prior to Access Placement

Consideration	Relevance
Patient History	
History of previous central venous catheter	Previous placement of a central venous catheter is associated with central venous stenosis.
Dominant arm	To minimize negative impact on quality of life, use of the nondominant arm is preferred.
History of pacemaker use	There is a correlation between pacemaker use and central venous stenosis.
History of severe congestive heart failure	Accesses may alter hemodynamics and cardiac output.
History of arterial or venous peripheral catheter	Previous placement of an arterial or venous peripheral catheter may have damaged target vasculature.
History of diabetes mellitus	Diabetes mellitus is associated with damage to vasculature necessary for internal accesses.
History of anticoagulant therapy or any coagulation disorder	Abnormal coagulation may cause clotting or problems with hemostasis of accesses.
Presence of comorbid conditions, such as malignancy or coronary artery disease, that limit patient's life expectancy	Morbidity associated with placement and maintenance of certain accesses may not justify their use in some patients.
History of vascular access	Previously failed vascular accesses will limit available sites for accesses; the cause of a previous failure may influence planned access if the cause is still present.
History of heart valve disease or prosthesis	Rate of infection associated with specific access types should be considered.
History of previous arm, neck, or chest surgery/trauma	Vascular damage associated with previous surgery or trauma may limit viable access sites.
Anticipated renal transplant from living donor	Temporary access may be sufficient.
Physical Examination	
Physical Examination of Arterial System	
Character of peripheral pulses, supplemented by hand-held Doppler evaluation when indicated	An adequate arterial system is needed for access; the quality of the arterial system will influence the choice of access site.
Results of Allen test	Abnormal arterial flow pattern to the hand may contraindicate the creation of a radial-cephalic fistula.
Bilateral upper extremity blood pressures	Pressures determine suitability of arterial access in upper extremities.
Physical Examination of Venous System	
Evaluation for edema	Edema indicates venous outflow problems that may limit usefulness of the associated potential access site or extremity for access placement.
Assessment of arm size comparability	Differential arm size may indicate inadequate veins or venous obstruction which should influence choice of access site.
Examination for collateral veins	Collateral veins are indicative of venous obstruction.
Tourniquet venous palpation with vein mapping	Palpation and mapping allow selection of ideal veins for access.
Examination for evidence of previous central or peripheral venous catheterization	Use of central venous catheters is associated with central venous stenosis; previous placement of venous catheters may have damaged target vasculature necessary for access.
Examination for evidence of arm, chest, or neck surgery/trauma	Vascular damage associated with previous surgery or trauma may limit access sites.
Cardiovascular Evaluation	
Examination for evidence of heart failure	Accesses may alter cardiac output.

patients with reduced kidney function in whom contrast agents should be avoided.

Arteriography is useful to avoid extremity ischemia in patients with diminished pulses in whom access in the extremity is still desired. However, the Work Group concluded that arteriography is only rarely required.

GUIDELINE 3

Selection of Permanent Vascular Access and Order of Preference for Placement of AV Fistulae

- A. The order of preference for placement of AV fistulae in patients with kidney failure who will become hemodialysis dependent is:
 1. A wrist (radial-cephalic) primary AV fistula (**Evidence**)
 2. An elbow (brachial-cephalic) primary AV fistula (**Evidence/Opinion**)
- B. If it is not possible to establish either of these types of fistula, access may be established using:
 1. An arteriovenous graft of synthetic material (eg, PTFE) (**Evidence**) or
 2. A transposed brachial basilic vein fistula (**Evidence**)
- C. Cuffed tunneled central venous catheters should be discouraged as permanent vascular access.

Rationale Wrist (radial-cephalic) and elbow (brachial-cephalic) primary fistulae are the preferred types of access because of the following characteristics:

- A. Excellent patency once established^{13,18,36-43}
- B. Lower complication rates compared to other access options,^{13,18,36-43} including lower incidence of conduit stenosis, infection, and vascular steal phenomenon
- C. Lower morbidity associated with their creation
- D. Improved performance (ie, flow) over time

The Work Group concluded that the advantages of wrist and elbow primary AV fistulae, listed above, outweigh the following potential disadvantages:

- A. The vein may fail to enlarge and increase blood flow to satisfactory levels (ie, fail to mature).^{13,18,43}

- B. Comparatively long maturation times—1 to 4 months—must elapse following creation of these fistulae before they can be used. Thus, the access must be created several months in advance of the anticipated need for dialysis or an alternative temporary method of vascular access must be used while the fistula matures (see Guideline 7: Preservation of Veins for AV Access, and Guideline 8, Timing of Access Placement).
- C. In some individuals, the vein may be more difficult to cannulate than an AV graft.
- D. The enlarged vein may be visible in the forearm and perceived as cosmetically unattractive.

The wrist fistula is the first choice of access type because of the following advantages:

- A. It is simple to create.
- B. It preserves more proximal vessels for future access placement.^{13,18,43}
- C. It has few complications. Specifically, the incidence of vascular steal is low, and in mature fistulae, thrombosis and infection rates are low.^{18,39,40}

The only major disadvantage of the wrist (radial-cephalic) fistula is a lower blood flow rate compared to other fistula types. If adequate flow to support the hemodialysis prescription is not achieved within 4 months with a radial-cephalic fistula, then another type of access should be established (see Guideline 8: Timing of Access Placement, and Guideline 9: Access Maturation).

The elbow (brachial-cephalic) primary arteriovenous fistula is the second choice for initial placement of an access. Its advantages include^{41,44-47}:

- A. It has a higher blood flow compared to the wrist fistula.
- B. The cephalic vein in the upper arm is easy to cannulate and is easily covered, providing a potential cosmetic benefit.

The disadvantages of the elbow (brachial-cephalic) primary AV fistula include:

- A. It is slightly more difficult to create surgically than a radial-cephalic fistula.
- B. It may result in more arm swelling than a radial-cephalic fistula.

- C. It is associated with an increased incidence of steal compared to a radial-cephalic fistula.

If a wrist or elbow fistula cannot be created, a dialysis AV graft using synthetic materials (PTFE or others) or a transposed brachial-basilic fistula is the next choice (see Guideline 4: Type and Location of Dialysis AV Graft Placement). Transposed brachial-basilic fistulae have several disadvantages:

- A. The transposition procedure may create significant arm swelling and patient pain.
- B. They have a higher incidence of steal and arm swelling than other fistula types.

Tunneled cuffed catheters have a shorter use-life and more complications than AV accesses (see Guideline 23: Treatment of Tunneled Cuffed Catheter Dysfunction, and Guideline 26: Treatment of Infection of Tunneled Cuffed Catheters).

GUIDELINE 4

Type and Location of Dialysis AV Graft Placement

If a primary AV fistula cannot be established, a synthetic AV graft is the next preferred type of vascular access (see Guideline 3: Selection of Permanent Vascular Access and Order of Preferences for Placement of AV Fistulae). **(Evidence)**

Polytetrafluoroethylene (PTFE) tubes are preferred over other synthetic materials. **(Evidence/Opinion)**

There is no convincing evidence to support tapered over uniform tubes, externally supported over unsupported grafts, thick- versus thin-walled configurations, or elastic versus nonelastic material. **(Opinion)**

Grafts may be placed in straight, looped, or curved configurations. Designs that provide the most surface area for cannulation are preferred. **(Opinion)**

Location of graft placement is determined by each patient's unique anatomical restrictions, the surgeon's skill, and the anticipated duration of dialysis. **(Opinion)**

Rationale Dialysis AV grafts have the following advantages:

- A. Large surface area available for cannulation^{36,48-50}

- B. Technically easy to cannulate³⁶

- C. Short lag-time from insertion to maturation (in general, not less than 14 days should elapse prior to cannulation to allow healing and incorporation of the graft into local tissues^{14,36,51}; see Guideline 9: Access Maturation)

- D. Multiple insertion sites available^{14,16,36,38,49,50,52,53}

- E. Variety of shapes and configurations available to facilitate placement^{14,16,36,38,48-50,54-56}

- F. Easy for the surgeon to handle, implant, and construct the vascular anastomoses^{14,16,36,50,51,54,57-65}

- G. Comparatively easy to repair surgically^{16,40,53,62,66,67}

The sum of the available data supports PTFE grafts over other biologic and other synthetic materials based on lower risk of disintegration with infection, longer patency, better availability, and improved surgical handling. Biologic grafts (bovine heterografts) have higher reported rates of complications compared to PTFE grafts. Direct comparisons between PTFE and human umbilical cord vein grafts and other synthetic polymers have not been made.

Grafts using larger (ie, proximal) vessels have better flow and patency but can limit potential sites for future placement.^{14,18,43} A synthetic dialysis AV graft is expected to last 3 to 5 years⁴³ (see Guideline 36: Cumulative Patency Rate of Dialysis AV Grafts). Grafts using smaller, more peripheral vessels can experience more frequent thromboses that require treatment. However, these grafts have the advantage of preserving more proximal sites for new grafts, should this become necessary in the future.^{13,14,18,68} Thus, the Work Group was unable to reach a consensus on a preferred location for AV grafts. The two preferred graft site types are the antecubital loop graft and the upper arm curved graft.

Potential sites for arterial inflow include: radial artery at the wrist, brachial artery in the antecubital fossa, brachial artery in the lower portion of the arm, brachial artery just below the axilla, axillary artery, and femoral artery. Potential sites for venous outflow include: median antecubital vein, proximal and distal cephalic vein, basilic vein at the level of the elbow, basilic

vein at the level of the upper arm, axillary vein, jugular vein, and femoral vein.

GUIDELINE 5

Type and Location of Tunneled Cuffed Catheter Placement

- A. Tunneled cuffed venous catheters are the method of choice for temporary access of longer than 3 weeks' duration. (They also are acceptable for access of shorter duration.) In addition, some patients who have exhausted all other access options require permanent access via tunneled cuffed catheters. For patients who have a primary AV fistula maturing but need immediate hemodialysis, tunneled cuffed catheters are the access of choice. Catheters capable of rapid flow rates are preferred. (**Evidence/Opinion**)
- B. The preferred insertion site for tunneled cuffed venous dialysis catheters is the right internal jugular vein. Other options include: the right external jugular vein, the left internal and external jugular veins, subclavian veins, femoral veins, or translumbar access to the inferior vena cava. Subclavian access should be used only when jugular options are not available. Tunneled cuffed catheters should not be placed on the same side as a maturing AV access, if possible. (**Evidence**)
- C. Fluoroscopy is mandatory for insertion of all cuffed dialysis catheters. The catheter tip should be adjusted to the level of the caval atrial junction or into the right atrium to ensure optimal blood flow. (Atrial positioning is only recommended for catheters composed of soft compliant material, such as silicone.) (**Opinion**)
- D. Real-time ultrasound-guided insertion is recommended to reduce insertion-related complications. (**Evidence/Opinion**)
- E. There is currently no proven advantage of one cuffed catheter design over another. Catheters capable of a rapid blood flow rate are preferred. Catheter choice should be based on local experience, goals for use, and cost. (**Evidence/Opinion**)

Rationale Tunneled cuffed venous catheters have the following advantages for vascular access:

- A. Universally applicable
- B. Ability to insert into multiple sites
- C. Maturation time not required
- D. Venipuncture not required
- E. No hemodynamic consequences
- F. Ease and cost of catheter placement and replacement
- G. Ability to provide access over a period of months—improving chances of AV fistula maturation in patients who require immediate hemodialysis^{36,69-77}
- H. Ease of correcting thrombotic complications^{69,78-80}

Disadvantages of tunneled cuffed venous catheters relative to other access types include:

- A. High morbidity due to:
 1. Thrombosis^{70,78-80}
 2. Infection^{70,78,81}
- B. Risk of permanent central venous stenosis or occlusion^{20,22,70,82}
- C. Discomfort and cosmetic disadvantage of an external appliance
- D. Shorter expected use-life than other access types^{36,37,78,83}
- E. Lower blood flow rates, which will require longer dialysis times⁸⁴

Tunneled cuffed venous catheters should be placed preferentially in the right internal jugular vein because this site offers a more direct route to the caval atrial junction than the left-sided great veins. Catheter insertion and maintenance in the right internal jugular vein are associated with a lower risk of complications compared to other potential catheter insertion sites.⁸⁵⁻⁸⁷ Catheter placement in the left internal jugular vein potentially puts the left arm's vasculature in jeopardy. Catheter placement in the left internal jugular vein is associated with poor blood flow rates and high rates of stenosis and thrombosis.^{72,85} Femoral and translumbar vein placement are associated with higher infection rates compared to other sites.⁸⁸ Ultrasound insertion has been shown to limit insertion complications.^{89,90} Fluoroscopy allows ideal catheter tip placement to maximize blood flow.

Totally subcutaneous catheter based access

systems are undergoing clinical trials and hold promise for minimizing catheter infection rates. These devices use a subcutaneous port attached to a dialysis catheter (Lifesite [Vasca Inc, Tewksbury MA] and Dialock [Bioline Inc, Boston, MA]).

GUIDELINE 6

Acute Hemodialysis Vascular Access—Noncuffed Catheters

- A. Hemodialysis access of less than 3 weeks' duration should be obtained using a non-cuffed, or a cuffed, double-lumen percutaneously inserted catheter. (For cuffed catheters, see Guideline 5: Type and Location of Tunneled Cuffed Catheter Placement.) **(Evidence/Opinion)**
- B. These catheters are suitable for immediate use and should not be inserted before needed. **(Evidence)**
- C. Noncuffed catheters can be inserted at the bedside in the femoral, internal jugular, or subclavian position. **(Evidence)**
- D. The subclavian insertion site should not be used in a patient who may need permanent vascular access. **(Evidence)**
- E. Chest x-ray is mandatory after subclavian and internal jugular insertion prior to catheter use to confirm catheter tip position at the caval atrial junction or the superior vena cava and to exclude complications prior to starting hemodialysis. **(Evidence/Opinion)**
- F. Where available, ultrasound should be used to direct insertion of these catheters into the internal jugular position to minimize insertion-related complications. **(Evidence/Opinion)**
- G. Femoral catheters should be at least 19-cm long to minimize recirculation. Noncuffed femoral catheters should not be left in place longer than 5 days and should be left in place only in bed-bound patients. **(Evidence/Opinion)**
- H. Nonfunctional noncuffed catheters can be exchanged over a guidewire or treated with urokinase as long as the exit site and tunnel are not infected. (See protocols in Table III-2.) **(Evidence)**
- I. Exit site, tunnel tract, or systemic infections should prompt the removal of non-

Table III-2. Protocols for Urokinase Administration

NKF-K/DOQI Protocol for Urokinase Administration

1. Attempt to aspirate the occluded catheter lumen to remove heparin.
2. Steadily inject urokinase (1 mL or volume sufficient to fill lumen) with 3 mL or other small syringe into the occluded catheter lumen (urokinase 5,000 U/mL).
3. If needed, fill remainder of the catheter lumen with saline in the same manner (eg, for a 1.3 mL catheter lumen use 1 mL urokinase and 0.3 mL saline).
4. Add 0.3 mL saline every 10 minutes $\times$ 2 to move active urokinase to distal catheter.
5. Aspirate catheter.
6. Repeat procedure if necessary.

Manufacturer's Protocol for Urokinase Administration

1. Attempt to aspirate the occluded catheter lumen to remove heparin.
2. Steadily inject urokinase (1 mL or volume sufficient to fill lumen) with 3 mL or other small syringe into the occluded catheter lumen (urokinase 5,000 U/mL).
3. Fill entire catheter lumen (urokinase 5,000 U/mL).
4. After 30 minutes, aspirate catheter. May be repeated as needed.

NOTE. Numerous protocols for urokinase administration are in use. These are two examples.

cuffed catheters. Treatment guidelines for catheter infection are discussed in Guideline 15, Catheter Care and Accessing the Patient's Circulation. **(Evidence/Opinion)**

Rationale Noncuffed, double-lumen catheters are suitable for percutaneous bedside insertion and provide acceptable blood flow rates (250 mL/min) for temporary hemodialysis.^{22,36,69} These catheters are suitable for immediate use but have a finite use-life and therefore should not be inserted until they are needed.^{22,36,69} The rate of infection for internal jugular or subclavian noncuffed catheters suggests that they should be used for no more than 3 weeks.^{22,36,69,91} The infection and dislodgment rates for femoral catheters require that they be left in place for no more than 5 days and only in bed-bound patients with good exit-site care. To minimize recirculation, femoral catheters should be at least 19-cm long to reach the inferior vena cava.⁹² The Work Group believes that longer durations of hemodialysis are best served by tunneled cuffed catheters because they are associated with lower infection rates and higher blood flow rates.^{22,36,69-71,73-75,77,91,93} Noncuffed catheters may be used for up to 3 weeks.

Ultrasound-directed cannulation minimizes insertion complications⁹⁴⁻⁹⁶ and should be used where available. In addition, the use of a post-insertion chest x-ray after internal jugular or subclavian insertion confirms the position of the catheter tip in the superior vena cava and allows evaluation for pneumothorax and hemothorax.^{26,36,69,73,97-101}

Thrombosed, noncuffed catheters can be exchanged over a guidewire or treated with urokinase.^{69,70} (See protocols in Table III-2.) Infection of any sort—exit site, tunnel tract, or systemic—requires removal of the catheter as well as antibiotic treatment as outlined in Guideline 15: Catheter Care and Accessing the Patient's Circulation, for tunneled cuffed catheters. The absence of a cuff requires removal of the catheter to prevent bacteremia mediated by bacterial migration down the external surface of the catheter.

GUIDELINE 7

Preservation of Veins for AV Access

- A. Arm veins suitable for placement of vascular access should be preserved, regardless of arm dominance. Arm veins, particularly the cephalic veins of the nondominant arm, should not be used for venipuncture or intravenous catheters. The dorsum of the hand should be used for intravenous lines in patients with chronic kidney disease. When venipuncture of the arm veins is necessary, sites should be rotated. (**Opinion**)
- B. Instruct hospital staff, patients with progressive kidney disease (creatinine >3 mg/dL), and all patients with conditions likely to lead to ESRD to protect the arms from venipuncture and intravenous catheters. A Medic Alert bracelet should be worn to inform hospital staff to avoid IV cannulation of essential veins. (**Opinion**)
- C. Subclavian vein catheterization should be avoided for temporary access in all patients with kidney failure due to the risk of central venous stenosis. (**Evidence**)

Rationale Venipuncture complications of veins potentially available for vascular access may render such vein sites unsuitable for construction of a primary AV fistula.

Patients and healthcare professionals should

be educated about the need to preserve veins to avoid loss of potential access sites in the arms and to maximize chances for successful AV fistula placement and maturation.

Subclavian vein catheterization is associated with central venous stenosis.^{20,26,102} Significant subclavian vein stenosis will generally preclude the use of the entire ipsilateral arm for vascular access. Thus, subclavian vein catheterization should be avoided for temporary access in patients with kidney failure.

GUIDELINE 8

Timing of Access Placement

- A. Patients with chronic kidney disease should be referred for surgery to attempt construction of a primary AV fistula when their creatinine clearance is <25 mL/min, their serum creatinine level is >4 mg/dL, or within 1 year of an anticipated need for dialysis. The patient should be referred to a nephrologist prior to the need for access to facilitate kidney failure treatment and for counseling about modes of ESRD care, including hemodialysis, peritoneal dialysis, and renal transplantation. (**Opinion**)
- B. A new primary fistula should be allowed to mature for at least 1 month, and ideally for 3 to 4 months, prior to cannulation. (**Opinion**)
- C. Dialysis AV grafts should be placed at least 3 to 6 weeks prior to an anticipated need for hemodialysis in patients who are not candidates for primary AV fistulae. (**Opinion**)
- D. Hemodialysis catheters should not be inserted until hemodialysis is needed. (**Evidence/Opinion**)

Rationale Both the size and anatomical qualities of venous and arterial components of primary AV fistulae can influence the fistulae maturation time. An aggressive policy of primary AV fistulae creation may result in failures in patients with marginal anatomy. However, timely attempts to create primary AV fistulae before the anticipated need for dialysis will allow adequate time for the fistulae to mature, and will allow sufficient time to perform another vascular access procedure if the first attempt fails, thus avoiding the need for temporary access. Early

referral of the patient with chronic kidney disease to a nephrologist is needed to facilitate kidney failure therapy with medications and diets that preserve kidney function. In addition, counseling patients on ESRD treatment options is essential to plan for ideal access (ie, peritoneal, and hemodialysis access).

The Work Group's consensus is that maturation of an AV graft access site—defined as reduction of surgically induced swelling and the graft's adherence to its tunnel tissue—usually requires about 3 weeks. Thus, ideally, AV grafts should be placed 3 to 6 weeks prior to use.

Cuffed and uncuffed catheters are acceptable for short-term (<3 weeks) use. Tunneled cuffed catheters are the method of choice for temporary access of greater than 3 weeks' duration.

Catheters are suitable for immediate use. To maximize their use-life, they should not be inserted until needed.

GUIDELINE 9

Access Maturation

- A. A primary AV fistula is mature and suitable for use when the vein's diameter is sufficient to allow successful cannulation, but not sooner than 1 month (and preferably 3 to 4 months after construction). **(Opinion)**
- B. The following procedures may enhance maturation of AV fistulae:
 1. Fistula hand-arm exercise (eg, squeezing a rubber ball with or without a lightly applied tourniquet) will increase blood flow and speed maturation of a new native AV fistula. **(Opinion)**
 2. Selective obliteration of major venous side branches will speed maturation of a slowly maturing AV fistula. **(Opinion)**
 3. When a new native AV fistula is infiltrated (ie, presence of hematoma with associated induration and edema), it should be rested until swelling is resolved. **(Opinion)**
- C. PTFE dialysis AV grafts should not routinely be used until 14 days after placement. Cannulation of a new PTFE dialysis AV graft should not routinely be attempted, even 14 days or longer after placement, until swelling has gone down enough

to allow palpation of the course of the graft. Ideally, 3 to 6 weeks should be allowed prior to cannulation of a new graft.

(Opinion)

- D. Patients with swelling that does not respond to arm elevation or that persists beyond 2 weeks after dialysis AV access placement should receive a venogram or other noncontrast study to evaluate central veins. **(Opinion)**
- E. Cuffed and uncuffed hemodialysis catheters are suitable for immediate use and do not require maturation time. **(Evidence)**

Rationale A vein must be mature, both physically and functionally, prior to use for vascular access. The time required for fistula maturation varies among patients. The Work Group does not advise use of the fistula within the first month after construction because premature cannulation of a fistula may result in a higher incidence of infiltration with associated compression of the vessel by hematoma and permanent loss of the fistula. Allowing the fistula to mature for 3 to 4 months before use may be ideal; however, the Work Group did not reach consensus on this topic.

Although there are no definitive data in the literature, any intervention that increases blood flow to the extremity may improve the chances of successful fistula development. Therefore, regular hand-arm exercises, with or without a lightly applied tourniquet, are recommended until the fistula matures. Failure of a fistula to mature is occasionally due to venous side branches that drain critical flow from the primary vessel. Ligating these side branches may result in successful maturation; however, the Work Group was not unanimous on this topic.

Repetitive attempts to cannulate an infiltrated fistula carries a high risk of inaccurate cannulation, which may further exacerbate the existing swelling and possibly lead to permanent loss of the access. Rather, the Work Group recommends that infiltrated fistulae be rested, and if required, other access established (eg, temporary or cuffed catheter), until the swelling has subsided and the vessel is sufficiently mature to allow successful cannulation. In some instances, use of an AV fistula can begin with placement of the arterial

needle only, with return flow accomplished by means of a catheter.

The Work Group concluded that cannulation of a PTFE dialysis AV graft within 14 days after insertion should be avoided because adhesion of the subcutaneous tunnel and graft has not occurred; potential hematoma and bleeding into the graft tunnel may ruin the access site. Dialysis AV grafts may be considered mature when swelling of the access site has reduced to the point that its course is easily palpable, but not less than 14 days after placement. Attempting to cannulate a new PTFE dialysis AV graft in an edematous arm may lead to hematoma formation and graft laceration (graft wall damage) from inaccurate needle insertion. Some practitioners argue that grafts may be cannulated immediately if the tunnel is carefully constructed. The Work Group cannot recom-

mend early cannulation until randomized trials of graft patency show similar long-term patency with immediate and delayed cannulation.

Swelling and edema of the extremity are expected following graft insertion due to changes in local hemodynamics and soft tissue injury secondary to tunnel creation. Edema of an extremity following AV graft insertion may also be an indication of an occult central venous stenosis or occlusion,¹⁰³ if the edema does not resolve over time with arm elevation. Therefore, venography or other noncontrast studies should be performed if edema and swelling persist beyond 2 weeks after graft insertion.

Erythema of a new dialysis AV graft should not prevent its use, as long as the redness is limited to the path of the graft. Erythema along the path of the graft suggests surgical inflammation rather than infection.

II. Monitoring, Surveillance, and Diagnostic Testing

GUIDELINE 10

Definition of Terms

As they are used in relation to dialysis vascular access, the following terms will apply:

Monitoring—This term refers to the examination and evaluation of the vascular access by means of physical examination to detect physical signs that would suggest the presence of pathology.

Surveillance—This term refers to periodic evaluation of the vascular access by means of tests, that may involve special instrumentation, for which an abnormal test result suggests the presence of pathology.

Diagnostic Testing—This term refers to testing that is prompted by some abnormality or other medical indication and which is undertaken to diagnose the presence of pathology.

Monitoring Dialysis AV Grafts

Physical examination of an access graft should be performed weekly and should include, but not be limited to, inspection and palpation for pulse and thrill at the arterial, mid, and venous sections of the graft. (**Opinion**)

The Work Group recommends an organized monitoring approach with regular assessment of clinical parameters of the AV access and dialysis adequacy. Data from the clinical assessment and dialysis adequacy measurements should be collected and maintained for each patient's access and made available to all staff. The data should be tabulated and tracked within each dialysis

Table III-3. Access Flow Protocol Surveillance

Access flow measured by ultrasound dilution, conductance dilution, thermal dilution, doppler or other technique should be performed monthly. The assessment of flow should be performed during the first 1.5 hours of the treatment to eliminate error caused by decreases in cardiac output related to ultrafiltration. The mean value of 3 separate determinations performed at a single treatment should be considered the access flow.

AV Graft and AV Fistula

Access Flow less than 600 mL/min, the patient should be referred for fistulogram.

Access Flow less than 1,000 mL/min that has decreased by more than 25% over 4 months should be referred for fistulogram.

center as part of a Quality Assurance/Continuous Quality Improvement (QA/CQI) program. (**Opinion**)

Surveillance of AV Grafts

Prospective surveillance of AV grafts for hemodynamically significant stenosis, when combined with correction, improves patency and decreases the incidence of thrombosis. (**Evidence**) Techniques, not mutually exclusive that can be used in surveillance for stenosis in AV grafts include, in order of decreasing preference:

Preferred

- Intra-access flow (Protocol provided in Table III-3) (**Evidence**)
- Static venous dialysis pressure (Protocol provided in Table III-4 and Fig III-1) (**Evidence**)

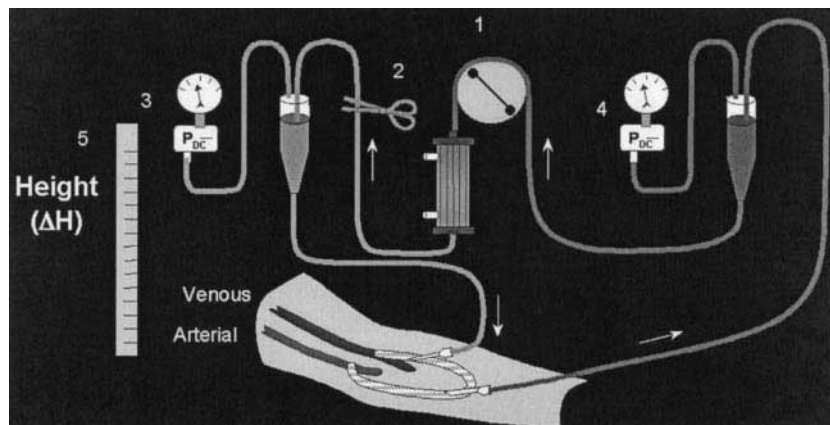


Fig III-1. Arterial and venous pressure monitoring.

Table III-4. Static Intra-Access Pressure (IAP) Surveillance Protocol

1. Establish a baseline when the access has matured and shortly after the access is first used. Trend analysis is more useful than any single measurement.
2. Assure that the zero setting on the pressure transducers of the dialysis delivery system being used has been calibrated to be accurate within ± 5 mm Hg. If uncertain check the calibration (Step 8).
3. Measure the mean arterial blood pressure (MAP) in the arm contralateral to the access.
4. Enter the appropriate output or display screen where venous and arterial pressures can be visualized (this varies for each dialysis delivery system). If a gauge is used to display pressures, the pressure can be read from the gauge.
5. Stop the blood pump and cross clamp the venous line just proximal to the venous drip chamber with a hemostat (this avoids having to stop ultrafiltration for the brief period needed for the measurement). On the arterial line, no hemostat is needed since the occlusive roller pump serves as a clamp.
6. Wait 30 seconds until the venous pressure is stable, then record the arterial and venous intra-access pressure (IAP) values. The arterial segment pressure can only be obtained if a pre-pump drip chamber is available and the dialysis system is capable of measuring absolute pressures greater than 40 mm Hg.
7. Unclamp the venous return line and restore the blood pump to its previous value.
8. If uncertain about the accuracy of the zero value on the pressure transducers, clamp the tubing from the drip chamber(s) to the pressure transducer protector(s). Pull off the pressure protector(s) from their nipples and record the zero value(s), P_0 (these are usually close to zero, but may deviate by 10 mm Hg or more below or above zero). Replace the pressure transducer(s) protector(s) and unclamp the line(s).
9. Determine the offset pressure(s), P_{offset} , between the access and the drip chamber(s) either by direct measurement (A) or using a formula (B) based on the difference in height between the top of the drip chamber and the top of the arm rest of the dialysis chair (Δ).
 - A. Measure the height from the venous or arterial needle to the top of the blood in the venous drip chamber in cm. The offset in Hg = height (cm) $\times$ 0.76. For practical purposes the same value can be used for both if the drip chambers are at the same height.
 - B. Use the formula, offset in mm Hg = $3.6 + 0.35 \times \Delta$. The same value can be used for both if the drip chambers are the same height. If the drip chambers are not at equal heights, the arterial and venous height offsets must be determined individually. In a given patient with a given access the height offsets need to be measured only once and then used until the access location is altered by construction of a new access.
10. Calculate the normalized arterial and venous segment static intra-access pressure ratio(s), P_{IA} .
 Arterial $P_{IA} = (\text{arterial IAP} + \text{arterial } P_{\text{offset}} - \text{arterial } P_0) / \text{MAP}$
 Venous $P_{IA} = (\text{venous IAP} + \text{venous } P_{\text{offset}} - \text{venous } P_0) / \text{MAP}$

NOTE. If the P is less than zero, algebraically subtracting a negative number is equivalent to adding the absolute number.

Interpretation: Venous outlet stenosis can be detected with venous P_{IA} alone. Trend analysis is more useful than any single measurement. The higher the degree of stenosis at the outlet, the greater is the venous (P_{IA}) pressure ratio. Strictures between the area of arterial and needle cannulation cannot be detected by measuring venous (P_{IA}) pressure alone (1). Detection of these lesions requires the simultaneous measurement of pressures from both the arterial and venous needles. Central stenoses that have collateral circulation may have "normal pressures," but these usually present with significant ipsilateral edema. Accesses can be classified into the categories listed in the table below using the equivalent P_{IA} ratios from the arterial or venous needles; the criteria must be met on each of two consecutive weeks to have a high likelihood of a 50% diameter lesion. The criterion in bold type is the primary criterion for the location of the stenosis, the other is supportive.

Access Type	Graft	Graft	Native	Native
Normalized P_{IA}	Arterial Ratio	Venous Ratio	Arterial Ratio	Venous Ratio
Normal	0.35-0.74	0.15-0.49	0.13-0.43	0.08-0.34
Stenosis				
Venous outlet	≥ 0.75	≥ 0.5	> 0.43 or	≥ 0.35
Intra-access	≥ 0.75 and	< 0.5	> 0.43 and	≤ 0.35
Arterial Inflow	< 0.3	NA	< 0.13 + clinical findings	NA

Patients who develop a progressive and reproducible increase in venous or arterial segment > 0.25 above their previous baseline irrespective of access type are also likely to have a hemodynamically significant lesion. Intra-access strictures are usually characterized by the development of a difference between the arterial and venous pressure ratios > 0.5 in grafts or > 0.3 in native fistula.

Table III-5. Dynamic Venous Dialysis Pressure Surveillance Protocol

- Establish a baseline by initiating measurements when the access is first used.
- Measure venous dialysis pressure from the hemodialysis machine at Qb 200 mL/min during the first 2 to 5 minutes of hemodialysis at every hemodialysis session.
- Use 15-gauge needles (or establish own protocol for different needle size).
- Assure that the venous needle is in the lumen of the vessel and not partially occluded by the vessel wall.
- Pressure must exceed the threshold three times in succession to be significant.
- Assess at the same level relative to hemodialysis machine for all measurements.

Interpretation of Result: Three measurements in succession above the threshold are required to eliminate the effect of variation caused by needle placement. Hemodialysis machines measure pressure with different monitors and tubing types and lengths. These variables, as well as needle size, influence venous dialysis pressure. The most important variable affecting the dynamic pressure at a blood flow of 200 mL/min is the needle gauge.^{9,129} It is essential to set thresholds for action based on machine manufacturer, tubing type, and needle gauge.

Using 15-gauge needles, the threshold that indicates elevated pressure (and therefore the likely presence of a hemodynamically significant venous outlet stenosis) for Cobe Centry 3 machines is a pressure of 125 mmHg, whereas the threshold for Gambro AK 10 machines is a pressure of 150 mmHg. Data for Baxter, Fresenius, Althin, and other dialysis machines are not available but are likely to be similar to those of the Cobe Centry 3 if the same gauge venous needle is used. Trial and error at each institution will determine each unit's threshold pressure.

Trend analysis is more important than any single measurement. Upward trends in hemodialysis pressure over time are more predictive than absolute values. Each unit should establish its own venous pressure threshold values.

Patients with progressively increasing pressures or those who exceed the threshold on three consecutive hemodialysis treatments should be referred for venography.

Acceptable

C. Dynamic venous pressures (Protocol provided in Table III-5) (**Evidence**)

Other studies or information that can be useful in detecting AV graft stenosis include:

- D. Measurement of access recirculation using urea concentrations (see Guideline 12: Recirculation Methodology, Limits, Evaluation, and Follow-up) (**Evidence**)
- E. Measurement of recirculation using dilution techniques (nonurea-based) (**Evidence**)

F. Unexplained decreases in the measured amount of hemodialysis delivered (URR, Kt/V) (**Evidence**)

G. Physical findings of persistent swelling of the arm, clotting of the graft, prolonged bleeding after needle withdrawal, or altered characteristics of pulse or thrill in a graft (**Evidence/Opinion**)

H. Elevated negative arterial pre-pump pressures that prevent increasing to acceptable blood flow^{104,105} (**Evidence/Opinion**)

I. Doppler ultrasound (**Evidence/Opinion**)

Diagnostic Testing in AV Grafts

Persistent abnormalities in any of these parameters should prompt referral for venography. (**Evidence**)

Rationale Physical examination can be used as a monitoring tool to exclude low flows associated with impending graft failures.¹⁰⁶⁻¹⁰⁸

Access flow determines the characteristics of pulse, thrill, and bruit. Palpable thrill at the arterial, mid, and venous segments of the graft predicts flows >450 mL/min.¹⁰⁸ A pulse suggests lower flows. An intensification of bruit suggests a stricture or stenosis.¹⁰⁸

In dialysis AV grafts, thrombotic events result primarily from progressive venous outflow stenosis.^{9,13,66,103,109-113} Thrombotic events that cannot be resolved are the leading cause of access loss. These stenoses are caused by intimal and fibromuscular hyperplasia in the venous outflow tract, typically at the vein graft anastomosis.^{9,13,66,103,109,111-113} As such stenoses increase in severity, they cause an increase in intra-access pressure with an accompanying decrease in blood flow.¹¹⁴ It has been shown that when access flow is measured repeatedly, trends of decreasing flow are predictive of access stenosis.¹¹⁵ Grafts with access blood flows less than 600 mL/min have a higher rate of access thrombosis than grafts with flow rates greater than 600 mL/min.¹¹⁶⁻¹¹⁸ Recently, several investigators have shown that a trend of decreasing access flow is more predictive of venous stenoses than any single measurement of access flow (see Table III-3). The measurement of access flow has also been shown to be a valuable tool in determining the success of a therapeutic intervention. Failure to increase access flow by at least 20% following an interven-

Table III-6. Patient Education Basics

All patients should be taught how to:

1. Compress a bleeding access
2. Seal the site of a central venous catheter (CVC) with ointment to keep air embolus from entering
3. Wash skin over access with soap and water daily and before dialysis
4. Recognize signs and symptoms of infection
5. Select proper methods for exercising AV fistula arm with some resistance to venous flow
6. Palpate for thrill/pulse daily and after any episodes of hypotension, dizziness, or lightheadedness
7. Listen for bruit with ear opposite access if cannot palpate for any reason

All patients should know to:

1. Avoid carrying heavy items draped over the access arm or wearing occlusive clothing
2. Avoid sleeping on the access arm
3. Insist that staff rotate cannulation sites daily
4. Insure that staff are using proper techniques in preparing skin prior to cannulation
5. Report any signs and symptoms of infection or absence of bruit/thrill to dialysis personnel immediately

tion reflects failure of the intervention to correct the underlying problem.^{208,209}

Because the development and severity of stenosis evolve to varying degrees among patients over time, the likelihood of detecting a hemodynamically significant stenosis increases if the Surveillance test is repeated. Therefore, surveillance should be performed at intervals of 1 month or less—depending on the complexity and cost—to detect access dysfunction early and to permit sufficient lead-time for intervention. The Work Group concluded that trend analysis may be as important as any individual value for any monitoring technique.

Intervention with percutaneous transluminal angioplasty (PTA) or surgical revision to correct stenoses dramatically reduces the rate of AV graft thrombosis and loss.^{9,103,109,113,119}

Sequential timely repetitive measurement of access flow is the preferred method for surveillance of AV grafts. To date, Doppler flow,^{115-117,120} ultrasound dilution,^{118,121,122} and magnetic resonance¹²³ have been the most extensively evaluated. All require specialized devices. Although Doppler studies can be predictive of access stenosis and the likelihood for failure,^{120,121} frequency of measurement may be limited by expense. In addition, inter-observer variability in measurement of Doppler flow in

some instances can reduce the reliability of Doppler flow measurement.¹²⁴ Variation in Doppler flow measurements performed by machines produced by different manufacturers also occurs. Magnetic resonance flow is accurate but expensive. Both Doppler flow and magnetic resonance are difficult to perform during dialysis sessions. In contrast, flow measurements performed by ultrasound velocity and other techniques using blood dilution are reliable and valid^{118,121,122} and can be done on-line during dialysis, thereby providing rapid feedback. The Work Group expects that, as technology improves, online access flow measurements using dilution technology will become more clinically applicable, and could supplant all other techniques by permitting accurate and inexpensive repetitive measurements at monthly intervals.

The Work Group believes that the value of routine use of any technique for detecting anatomic stenosis without concomitant measurement of access flow, venous pressure, recirculation, or other physiologic parameter has not been established.

Prospective Surveillance using dynamic or static venous dialysis pressures detects outflow stenoses. Both methods have acceptable sensitivity and specificity, are inexpensive, and are readily available.^{103,119} Using a standardized protocol (eg, measurements made with blood pump flow rates of 200 mL/min), dynamic venous pressure monitoring is easily performed with available methodology and existing equipment. Measuring venous pressure is the least expensive method

Table III-7. Protocol for Urea-Based Measurement of Recirculation

Perform test after approximately 30 minutes of treatment and after turning off ultrafiltration.

1. Draw arterial (A) and venous (V) line samples.
2. Immediately reduce blood flow rate (BFR) to 120 mL/min.
3. Turn blood pump off exactly 10 seconds after reducing BFR.
4. Clamp arterial line immediately above sampling port.
5. Draw systemic arterial sample (S) from arterial line port.
6. Unclamp line and resume dialysis.
7. Measure BUN in A, V, and S samples and calculate percent recirculation (R).

Recirculation Formula:

$$R = \frac{S - A}{S - V} \times 100$$

of Surveillance for stenosis.^{103,119} A protocol is provided in Tables III-4 and III-5.^{103,119} These techniques have been validated in prospective trials^{9,103,109,119,125,126} and are recommended weekly. Venous pressures (dynamic) while less predictive than flow measurements, have been validated and should continue to be used until flow measurements are widely available. Shortcomings of dynamic venous pressure techniques are the need to standardize for blood tubing, needle size, and hemodialysis machine.^{9,103,109,119,125,126}

Surveillance protocols that use static venous dialysis pressure (ie, venous dialysis pressure at zero blood pump flow) are even more strongly predictive of outflow stenoses than dynamic pressure measurements, but these approaches currently require specialized devices.^{9,114} The Work Group believes that measurement of static pressure every 2 weeks is the maximum frequency feasible with current hemodialysis staffing patterns. New techniques, however, may eliminate these shortcomings.¹²⁷ If it becomes possible to adapt existing hemodialysis machines for static pressure measurement, then weekly measurement will be appropriate.

Trends in either dynamic or static venous dialysis pressure measurements are more predictive of access stenosis than any single pressure measurement.^{9,103,119} (See protocol provided in Tables III-4 and III-5.)

Increases in urea recirculation are also predictive of venous stenoses.^{113,128} However, the Work Group believes that recirculation is a relatively late predictor of access dysfunction. Urea measurement for the calculation of recirculation must be done under standardized conditions. Nonurea-based recirculation measurements are very accurate but require specialized devices (see Guideline 12: Recirculation Methodology, Limits, Evaluation, and Follow-Up).

Unexplained decreases in delivered dialysis dose, as measured by Kt/V or URR, are frequently associated with venous outflow stenoses.¹¹³ However, many other factors influence Kt/V and URR, making them less sensitive and less specific for detecting access dysfunction.

Regular assessment of physical findings (Monitoring) may supplement and enhance an organized surveillance program to detect access dys-

function.^{103,107,108} Specific findings predictive of venous stenoses include: edema of the access extremity, prolonged bleeding postvenipuncture (in the absence of excessive anticoagulation), and changes in the physical characteristics of the pulse or thrill in the graft.^{103,108} Physical examination is a useful screening tool to exclude low flow (<450 mL/min) in grafts with impending failure.¹⁰⁶⁻¹⁰⁸ A palpable thrill at the arterial, mid-graft, and venous segments is associated with flow >450 mL/min.¹⁰⁸ Conversion of thrill to pulse indicates lower flows. Intensification of bruit (higher pitch) indicates a stenosis.^{106,107} Therefore, in the context of proper needle position, an elevated negative arterial pre-pump pressure that prevents increasing the blood flow rate to the prescribed level is also predictive of arterial inflow stenoses.

When a test indicates the likely presence of a stenosis, venography or fistulography are used to confirm the lesion.

In addition to monitoring conducted by the professionals on the healthcare team, the patient and the patient's caregivers should be educated about simple emergency procedures and basic care of the access site (see Table III-6).

GUIDELINE 11

Monitoring Primary AV Fistulae for Stenosis

Primary AV fistulae should be monitored as outlined for dialysis AV grafts (see Guideline 10: Monitoring Dialysis AV Grafts for Stenosis).
(Opinion)

Direct flow measurements, if available, are preferable compared to more indirect measures.
(Evidence)

Methods appropriate for monitoring stenosis in grafts (eg, static and dynamic venous pressures) are not as accurate for monitoring in primary AV fistulae. **(Evidence)** Recirculation and Doppler analysis are of potential benefit.
(Opinion)

Rationale In primary AV fistulae, inadequate flow through the access is the primary functional defect predictive of thrombosis and access failure. Thus, flow measurements should be used when available to monitor for stenosis and thrombosis in AV fistulae.^{121,122} Stenoses in AV fistulae tend to occur more centrally—in the outflow tract at areas of vein bifurcation, pressure points,

and venous valves—rather than in close proximity to the venous outlet (as is the case with grafts).^{9,114} As a result, collateral veins draining an AV fistula develop, preventing a marked increase in pressures.^{9,114,130} Indirect measures of flow, such as dynamic and static venous dialysis pressure, are therefore less predictive of thrombosis and access failure in AV fistulae compared to AV grafts. Measurement of recirculation, on the other hand, becomes a more useful screening tool in AV fistulae compared to AV grafts because flow in AV fistulae, unlike AV grafts, can decrease to a level less than the prescribed blood pump flow (ie, less than 300 to 500 mL/min), while still maintaining access patency^{115,130} (see Guideline 12: Recirculation Methodology, Limits, Evaluation, and Follow-Up). Since pressure measurement and recirculation may be late predictors of access dysfunction in AV fistulae, Doppler ultrasound may be useful despite its increased cost. However, the absence of validation studies precludes Work Group recommendations at this time.

GUIDELINE 12

Recirculation Methodology, Limits, Evaluation, and Follow-Up

Recirculation should be measured using a nonurea-based dilutional method or by using the two-needle urea-based method. The three-needle peripheral vein method of measuring recirculation should not be used. **(Evidence)**

Any access recirculation is abnormal. Recirculation exceeding 10% using the recommended two-needle urea-based method, or 5% using a nonurea-based dilutional method, should prompt investigation of its cause. **(Evidence)**

If access recirculation values exceed 20%, correct placement of needles should be confirmed before conducting further studies. **(Evidence/Opinion)**

Elevated levels of access recirculation should be investigated using angiography (fistulography) to determine whether stenotic lesions are impairing access blood flow. **(Evidence)**

Rationale The three-needle, peripheral vein method for measuring recirculation overestimates access recirculation in an unpredictable manner and requires unnecessary venipuncture.¹³¹⁻¹³³ This is illustrated in Fig III-2,¹³⁴ which

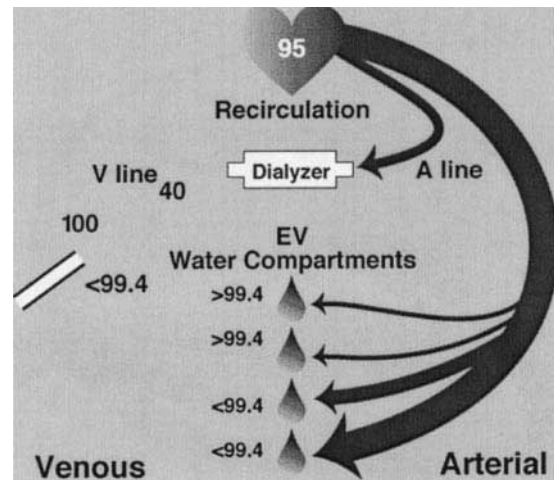


Fig III-2. Access and cardiopulmonary recirculation. The figure shows a simplified sketch of the dialysis circuit with an AV access depicting local access recirculation (dotted line with arrows) and cardiopulmonary recirculation. Cardiopulmonary recirculation is associated with an arteriovenous difference in BUN (100 versus 95 mg/dL) which results from dialyzed blood “short circuiting” the capillaries where blood is “refilled” with urea (95 to 99.4 mg/dL); this “short circuiting” decreases dialysis efficiency. This sketch includes regional blood flow inequalities and the resulting impact on BUN in veins draining poorly perfused (BUN >99.4 mg/dL) and well-perfused (BUN <99.4 mg/dL) areas. This venovenous disequilibrium increases late in dialysis when greater differences develop in urea concentrations among the regions of the body, a consequence of varying urea washout (regional blood flow model).¹³⁴ Reprinted with permission.¹³⁴

shows both the effect of regional blood flow differences (venovenous disequilibrium) and the effect of the return of a fraction of dialyzed blood to the dialyzer without passage through the tissues first (arteriovenous disequilibrium or cardiopulmonary recirculation). Because of these effects, the peripheral venous blood urea nitrogen (BUN) is substantially greater than the BUN in arterial blood. The use of a peripheral venous sample in place of an arterial sample overestimates actual access recirculation.

The urea-based method described uses two needles and avoids overestimation of recirculation (see Table III-7). The recommended approach for this method is simple and is based on two considerations. The dead space of arterial lines to the sampling port is less than 12 mL. Access recirculation generally does not occur (except for reversed needles) unless access blood flow rates are less than dialyzer blood pump flow

rates.¹³⁰ This conclusion is supported by studies using nonurea-based methods that show that recirculation is absent (0%) in a properly cannulated, well-functioning access.¹³⁵⁻¹³⁸ A blood flow rate of 120 mL/min for 10 seconds will clear the arterial line dead space. Sampling at this time will provide arterial blood prior to onset of rebound. The results using the recommended two-needle method should average zero (−5% to +5%) in patients with unimpaired accesses. Although nonurea-based dilutional methods are more accurate and avoid problems with cardiopulmonary recirculation, they require specialized devices,¹³⁸ which limit their applicability.

New vascular accesses are at particular risk for reversed needle placement due to a lack of familiarity with the access anatomy. Whenever possible, an access diagram that depicts the arterial and venous limbs should be obtained from the surgeon who constructed the access to aid in proper cannulation. If not available, the anatomy can be deduced by *temporarily* occluding the graft at its midportion. The portion retaining a pulse is the arterial limb.

The amount of recirculation occurring with reversed needles is usually substantial (>20%).

However, even with ideal sample timing and proper cannulation, laboratory variability in urea-based measurement methods will produce variability in calculated recirculation.¹³⁷ Therefore, individual recirculation values <10% using urea-based methods may be clinically unimportant. The Work Group believes they do not prompt further evaluation. Values >10% using urea-based recirculation measurement methods do require investigation. However, the Work Group's opinion is that values >5% using nonurea-based dilution techniques are a reliable indication of an abnormality and should prompt investigation into the cause.

Access recirculation in a properly cannulated access is a sign of low access blood flow¹³⁰ and is a marker for the presence of vascular access stenoses. Such stenoses can be corrected, thereby decreasing the risk of access thrombosis and prolonging access longevity.¹²⁸

Angiography/fistulography are used to establish the presence of the stenosis (see Guideline 10: Monitoring Dialysis AV Grafts for Stenosis, and Guideline 17: When to Intervene Dialysis AV Grafts for Venous Stenosis, Infection, Graft Degeneration, and Pseudoaneurysm Formation).

III. Prevention of Complications: Infection

GUIDELINE 13

Infection Control Measures

Staff and patient education should include instruction on infection control measures for all hemodialysis access sites. **(Opinion)**

Rationale In hemodialysis patients, poor personal hygiene is a risk factor for vascular access site infections.¹³⁹ Therefore, hemodialysis patients with poor personal hygiene habits should be taught how to improve and maintain their personal hygiene.

In addition, there is a higher rate of infection in hemodialysis patients when new or inexperienced dialysis staff manipulate the patient's vascular access.^{140,141} Because of this, all dialysis staff should be trained in infection control procedures (see Guideline 14: Skin Preparation Technique for Permanent AV Accesses, and Guideline 15: Catheter Care and Accessing the Patient's Circulation). Documenting educational materials and objectives must be part of the patient's records and staff orientation records.

Tracking the occurrence of infections can help identify the source and allow corrective action to be taken. Ongoing quality assurance, risk management, or CQI efforts should be in place to monitor the incidence of infection, to evaluate the response to patient and staff education, and to identify future educational needs.

GUIDELINE 14

Skin Preparation Technique for Permanent AV Accesses

A clean technique for needle cannulation should be used for all cannulation procedures. **(Evidence)** (See proposed skin preparation technique in Table III-8 and cannulation technique in Table III-9.)

Rationale Cannulation of an access site places the hemodialysis patient at risk for infection via bacterial contamination. Bacteria can be introduced directly into the patient's bloodstream by needle cannulation, leading to local infection of the access material (blood vessel or PTFE) and/or to bloodstream infection. Bloodstream infection increases morbidity and mortality in ESRD patients and must be prevented. Dialysis staff should comply with OSHA regulations, including hand

Table III-8. Skin Preparation Technique for Permanent AV Accesses

1. Locate and palpate the needle cannulation sites prior to skin preparation.
2. Wash access site using an antibacterial soap or scrub (eg, 2% chlorhexidine) and water.
3. Cleanse the skin by applying 70% alcohol and/or 10% povidone iodine using a circular rubbing motion.

Notes:

- Alcohol has a short bacteriostatic action time and should be applied in a rubbing motion for 1 minute immediately prior to needle cannulation.
- Povidone iodine needs to be applied for 2 to 3 minutes for its full bacteriostatic action to take effect and must be allowed to dry prior to needle cannulation.
- Clean gloves should be worn by the dialysis staff for cannulation. Gloves should be changed if contaminated at any time during the cannulation procedure.
- New, clean gloves should be worn by the dialysis staff for each patient.

washing and use of clean gloves during needle cannulation. Washing the access site with soap and water will decrease the patient's skin microflora that can be introduced inadvertently into the patient's bloodstream during needle cannulation.¹⁴²⁻¹⁴⁴

The use of 70% alcohol and/or 10% povidone iodine (see Table III-8) conforms to CDC guidelines for the prevention of intravascular device-related infections and is supported by the literature.^{142,145}

There is no literature to support the use of any specific technique for cannulation. The Work Group recommends the technique described in Table III-9.

GUIDELINE 15

Catheter Care and Accessing the Patient's Circulation

Catheter care and accessing the patient's circulation should be clean procedures.

- A. Hemodialysis catheter dressing changes and catheter manipulations that access the patient's bloodstream should only be performed by trained dialysis staff. **(Evidence/Opinion)**
- B. The catheter exit site should be examined at each hemodialysis treatment for signs of infection. **(Opinion)**

Table III-9. Technique for AV Fistula/AV Graft Cannulation^{146,147}

Technique	Rationale
After skin preparation, pull skin taut in opposite direction of needle insertion	• Compresses peripheral nerve endings between epidermis and dermis • Facilitates smoother incision of skin with less surface area contacting cutting edge of needle • Enables better stabilization of graft or vessel to be cannulated
Use approximately 45 degree angle of insertion for AV graft and approximately 25 degree angle for AV fistula	Less steep angles increase risk of dragging cutting edge of needle along surface of vessel. Steeper angles increase risk of perforating underside of vessel.
Once the vessel has been penetrated, there are basically three methods employed in extant practice: 1. Advance the needle slowly with cutting edge facing top of vessel and do not rotate axis 2. Immediately rotate the axis of the needle 180 degrees and advance slowly with cutting edge facing bottom of the vessel 3. Advance the needle to desired position, then rotate the axis 180 degrees	1. Any manipulation may traumatize the intima of the vessel 2. Rotating the axis avoids traumatizing the top of intima 3. Waiting to rotate axis avoids traumatizing top of vessel while needle is taped in place
Tape the needle at the same angle or one similar to the angle of insertion	Pressing the needle shaft flat against the skin moves the needle tip from the desired position within the vessel lumen
Remove needle at same or angle similar to angle of insertion, and NEVER APPLY PRESSURE BEFORE NEEDLE IS COMPLETELY OUT	Avoid trauma to any intima by dragging cutting edge along it. Avoid pressing cutting edge into intima when applying pressure for hemodialysis.

C. Catheter exit site dressings should be changed at each hemodialysis treatment. **(Opinion)**

D. Use of dry gauze dressing combined with skin disinfection, using either chlorhexidine or povidone iodine solution, followed by povidone iodine ointment or mupirocin ointment at the catheter exit site are recommended after catheter placement and at the end of each dialysis session. **(Evidence)**

E. Manipulating a catheter and accessing the patient's bloodstream should be performed in a manner that minimizes contamination (see Table III-10). **(Evidence)**

F. During catheter connect and disconnect procedures, nurses and patients should wear a surgical mask or face shield. Nurses should wear gloves during all connect and disconnect procedures. **(Opinion)**

Rationale Catheter dressing changes and manipulation place the patient at risk for infection. Infection rates increase when catheter dressing changes or manipulations are performed by inadequately trained staff.^{140,141,148}

The use of dry gauze dressing and povidone iodine and mupirocin ointment at the catheter

exit site can reduce the incidence of exit site infections,^{141,149-152} especially in patients who have nasal carriage *Staphylococcus aureus*. Certain manufacturers have indicated that the glycol constituents of ointment should not be used on their polyurethane catheters. A specific manufacturer's recommendation from Bard has been issued. Dry gauze dressings rather than transparent film dressings are recommended because trans-

Table III-10. Considerations for Accessing the Bloodstream Using Catheters

- The catheter hub caps or bloodline connectors should be soaked for 3 to 5 minutes in povidone iodine and then allowed to dry prior to separation.
- Catheter lumens should be kept sterile.
- To prevent contamination, the lumen and tip should never remain open to the air. A cap or syringe should be placed on or within the catheter lumen, while maintaining a clean field under the catheter connectors.
- Patients should wear a surgical mask for all catheter procedures that remove the catheter caps and access the patient's bloodstream.
- Dialysis staff should wear gloves and a surgical mask or face shield for all procedures that remove catheter caps and access the patient's bloodstream.
- A surgical mask for the patient and mask or face shield for the dialysis staff should be worn for all catheter dressing changes.

parent film dressings pose a greater threat of exit site colonization.¹⁴⁹ In patients with an allergy to povidone iodine, alternate agents such as polyan-timicrobial gel can be substituted.

Catheter infection can occur following transmission of hand or aerosolized bacterial contaminants. *Staphylococcus aureus* is the leading cause of catheter exit site infection and bacteremia in hemodialysis patients. Bacteremia and tunnel tract infections are the leading causes of catheter loss.^{78,153} Chronic hemodialysis patients are at increased risk of *S aureus* nasal carriage; the literature reports a 50% to 60% carriage rate in

hemodialysis patients.^{141,154-156} Nasal carriage may result in seeding the skin with autogenous *S aureus*, leading to catheter site infection, tunnel track infection, or bacteremia. Catheter placement near the patient's nose and mouth, such as occurs with subclavian or jugular vein catheters, exposes the patient's catheter exit site to nasal drainage/discharge and infectious airborne droplets. Methicillin-resistant *S aureus* may be transmitted in this mode. A surgical mask worn by the patient and nurse any time the catheter is accessed reduces the spread of infectious droplets and reduces contamination of the catheter site.

IV. Management of Complications: When to Intervene

GUIDELINE 16

Managing Potential Ischemia in a Limb Bearing an AV Access

All patients, particularly those in high-risk groups, should be monitored for the development of limb ischemia following AV access construction.

- A. Patients in high-risk groups (diabetic, elderly, those with multiple access attempts in an extremity) should be monitored closely for the first 24 hours postoperatively. Monitoring should include: **(Opinion)**
 1. Subjective assessment of complaints, including sensations of coldness, numbness, tingling, and impairment of motor function (not limited by postoperative pain)
 2. Objective assessment of skin temperature, gross sensation, and movement and distal arterial pulses in comparison to the contralateral side
 3. Teaching patients to immediately report any coldness, loss of motion, or significant reduction in sensation
- B. Patients with an established fistula should be assessed monthly. The following are recommended as part of this assessment: **(Opinion)**
 1. Obtaining an interval history of increased distal coldness or distal pain during dialysis, decreased sensation, weakness or other reduction in function, or skin changes
 2. Confirming any abnormalities by physical examination

Patients with new findings suggestive of ischemia (A.3 above) should be referred to a vascular access surgeon emergently. Reduced skin temperature, as an isolated finding, requires follow-up observation but no emergent intervention. **(Opinion)**

Rationale Patients with diabetes and/or those with abnormal arterial supply caused by prior vascular access, vascular anomalies, and/or atherosclerotic disease are at greatest risk for ischemia. Limb ischemia distal to an AV access can occur at any time, from a few hours to

months, following access construction. Severe ischemia can cause irreparable injury to nerves within hours and must be considered a surgical emergency. Mild ischemia—manifested by subjective coldness and paresthesias and objective reduction in skin temperature but with no loss of sensation or motion—is common and generally improves with time. Patients with mild ischemia should undergo symptom-specific therapy (eg, wearing a glove) and frequent physical examination, with special attention to subtle neurologic changes and muscle wasting.¹⁵⁷ Failure to improve may require surgical intervention with banding or access correction or ligation.

GUIDELINE 17

When to Intervene—Dialysis AV Grafts for Venous Stenosis, Infection, Graft Degeneration, and Pseudoaneurysm Formation

Appropriate intervention in AV grafts should be initiated upon identification of:

- A. Hemodynamically significant stenosis (see Guideline 10: Monitoring Dialysis Grafts for Stenosis) **(Evidence)**
- B. Infection—an infected graft should be treated surgically **(Evidence)**
- C. Graft degeneration and pseudoaneurysm formation—grafts should be surgically revised when:
 1. Severe degenerative changes of the graft or overlying skin are present. **(Opinion)**
 2. Skin above the graft is compromised. **(Opinion)**
 3. There is a risk of graft rupture due to poor eschar formation or there is evidence of spontaneous bleeding. **(Opinion)**
 4. Limited puncture sites are available due to the presence of a large (or multiple) pseudoaneurysm(s) (see Guideline 27: Treatment of Pseudoaneurysm of Dialysis AV Grafts). **(Opinion)**

Rationale Hemodynamically significant stenoses. Hemodynamically significant stenosis is defined as a $\geq 50\%$ reduction of normal vessel diameter (graft or draining venous system) ac-

accompanied by a hemodynamic, functional, or clinical abnormality, such as: elevated static or dynamic pressures, decreased blood flow, elevated access recirculation, a swollen extremity, or unexplained reduction in Kt/V (see Guideline 10: Monitoring Dialysis AV Grafts for Stenosis, and Guideline 11: Monitoring Primary AV Fistulae for Stenosis).

Venous stenosis increases the risk of thrombosis.^{117,119} Physiologically, venous stenosis increases resistance to blood flow, which in turn results in increased venous pressure, decreased blood flow and ultimately, thrombosis.^{9,119} When examined angiographically, more than 90% of thrombosed grafts are associated with venous stenosis.¹⁵⁸⁻¹⁶³ Moreover, the presence of venous stenosis reduces the efficiency of the dialysis treatment.^{113,128} Stenosis can and should be detected prospectively to allow swift, successful treatment (see Guideline 11: Monitoring Primary AV Fistulae for Stenosis, and Guideline 12: Recirculation Methodology, Limits, Evaluation, and Follow-Up).

Therapeutic interventions for *hemodynamically significant stenoses* reduce the rate of thrombosis and graft loss and prolong the average use-life of the access.^{9,30,109,119,164,165} The literature suggests that the long-term patency of AV grafts is improved if stenoses are treated prior to thrombus formation as opposed to undertaking angioplasty or surgical revision (with their respective needs for thrombolysis or thrombectomy) after thrombus occlusion of the access has occurred.

Prospective intervention currently is not warranted for anatomical stenoses found in AV grafts and draining veins that are *not* associated with a hemodynamic, functional, or clinical abnormality (such as elevated static or dynamic pressures); decreased blood flow; elevated access recirculation; or a swollen extremity.^{9,103,119} Prospective studies correcting 50% stenoses not associated with a hemodynamic, functional, or clinical abnormality have not been performed. Until these studies are performed, there is no convincing evidence that correction of asymptomatic 50% stenosis will decrease thrombosis.

When treatment of a thrombosed graft does not address the presence of an underlying venous

stenosis, there is a 90% or greater chance that the treatment will be inadequate and will result in rapid re-thrombosis.¹⁶³

Stenosis detected prior to access thrombosis is more responsive to therapy than stenoses detected postthrombosis (see Guideline 19: Treatment of Stenosis without Thrombosis in Dialysis AV Grafts and Primary AV Fistulae, and Guideline 21: Treatment of Thrombosis and Associated Stenosis in Dialysis AV Grafts). In a retrospective analysis, when thrombosis was treated with thrombolysis and PTA, 50% of grafts were patent 4 weeks later. In contrast, when the graft was still patent at the time of angioplasty, 50% of the grafts remained patent for 24 to 28 weeks.¹⁶⁶ Beathard¹⁰³ reported a 78.9% patency at 3 months for stenotic grafts treated prior to thrombus formation. In contrast, the primary patency rate for grafts averaged 40% when stenoses are corrected post-thrombosis.^{103,107,167}

Arterial stenosis associated with diminished access inflow, characterized by elevated negative pressure, should be evaluated and corrected (see Guideline 19: Treatment of Stenosis without Thrombosis in Dialysis AV Grafts and Primary AV Fistulae).

Infection. When infected, a dialysis AV graft should be treated surgically. An untreated access infection may lead to bacteremia, sepsis, hemorrhage, and death.^{14,16,38,168} Surgical exploration and removal of any infected graft or graft segment is necessary for resolution of the infection because the graft material acts as a foreign body unless eliminated^{13,14,16,38,53,169} (see Guideline 24: Treatment of Infection of Dialysis AV Grafts).

Graft degeneration and pseudoaneurysm formation. Degenerative changes that occur within a graft and the overlying skin, including pseudoaneurysm formation with progressive enlargement, can eventually compromise circulation to the skin above the graft. This can lead to incomplete hemostasis upon needle withdrawal and ultimately to graft rupture. Thus, these degenerative changes can lead to severe hemorrhage and potentially to exsanguination and death. The Work Group believes that large pseudoaneurysms can also prevent access to the adjacent areas of the

graft for needle placement, thereby limiting potential puncture sites.

GUIDELINE 18

When to Intervene—Primary AV Fistulae

Appropriate intervention in primary AV fistulae should be initiated upon identification of:

- A. Inadequate flow to support the prescribed dialysis blood flow (**Evidence/Opinion**)
- B. Hemodynamically significant venous stenosis (**Evidence**)
- C. Aneurysm formation—a primary AV fistula should be revised when an aneurysm develops if: (**Opinion**)
 - 1. The skin overlying the fistula is compromised.
 - 2. There is a risk of fistula rupture.
 - 3. Available puncture sites are limited.

Rationale Inadequate flow to support the prescribed dialysis blood flow. A primary AV fistula should be revised when its blood flow is inadequate to sustain adequate dialysis blood flow, as manifested by the inability to achieve the prescribed Kt/V within a reasonable dialysis duration. Low access blood flow has a major effect on the delivery of dialysis—

inadequate blood flow may result in inadequate dialysis, thereby increasing patient mortality and morbidity.^{170,171}

For native fistulae, significant stenoses do not always cause elevated dynamic or static pressures. They can result in decreased access flow and elevated recirculation in the absence of elevated dynamic or static pressures (see Guideline 10: Monitoring Dialysis AV Grafts for Stenosis, and Guideline 11: Monitoring Primary AV Fistulae for Stenosis).

Hemodynamically significant venous stenosis. In a primary AV fistula, the major physiologic effect of stenosis is low blood flow, which results in inefficient dialysis (see above). Low blood flow also increases the risk of thrombosis.¹⁰⁹

Treatment of hemodynamically significant venous stenosis prolongs the use-life of the fistula.^{109,112,119,165}

Aneurysm formation. Progressive enlargement of an aneurysm can eventually compromise the skin above the graft, leading to possible rupture. This can result in hemorrhage, exsanguination, and death. In the Work Group's opinion, large aneurysms can prevent access to the adjacent fistula for needle placement, thereby limiting potential puncture sites.

V. Management of Complications: Optimal Approaches for Treating Complications

BACKGROUND

Management of vascular access complications relies on a multidisciplinary approach involving nephrologists, nephrology nurses, vascular interventionists, and surgeons. The goal of these management efforts is the preservation of vascular access.

GUIDELINE 19

Treatment of Stenosis Without Thrombosis in Dialysis AV Grafts and Primary AV Fistulae

Stenosis Treatment:

- A. Stenoses that occur in a dialysis AV graft or primary AV fistula (venous outflow or arterial inflow) should be treated with percutaneous transluminal angioplasty or surgical revision if the stenosis is >50% of the lumen diameter and is associated with the following clinical/physiologic abnormalities: **(Evidence)**
 1. Previous thrombosis in the access
 2. Elevated venous dialysis pressure
 3. Abnormal urea or other recirculation measurements
 4. Abnormal physical findings
 5. Unexplained decrease in measurement of dialysis dose
 6. Decreasing access flow (see Guideline 17: When to Intervene Dialysis AV Grafts for Venous Stenosis, Infection, Graft Degeneration, and Pseudoaneurysm Formation, and Guideline 18: When to Intervene Primary AV Fistulae)
- B. Each dialysis center should determine which procedure (angioplasty versus surgical revision) is best for the patient based on the expertise at that center. **(Evidence/Opinion)**
- C. Stenosis, as well as the clinical parameters used to detect it, should return to within acceptable limits following intervention. **(Evidence)**

Stenosis Treatment Outcomes:

- A. Centers should monitor stenosis treatment outcomes on the basis of patency; reason-

able patency goals (for the center as a whole) for PTA and surgical revision in the absence of thrombosis are:

PTA 50% unassisted patency* at 6 months **(Evidence)**; no more than 30% residual stenosis postprocedure and resolution of physical indicator(s) of stenosis

Surgical revision 50% unassisted patency at 1 year **(Opinion)**

- B. If angioplasty is required more than 2 times within 3 months, the patient should be referred for surgical revision if such an option is available and if the patient is a good surgical candidate. **(Opinion)**
- C. Stents are useful in selected instances (eg, limited residual access sites, surgically inaccessible lesions, contraindication to surgery) when PTA fails. **(Evidence)**

Rationale Correction of venous stenoses of >50% lumen diameter associated with a clinical/physiologic variable correlates with a significant decrease in the rate of fistula thrombosis and an improvement in access patency.^{9,103,109,119} Eighty-five percent to 90% of AV access thromboses are associated with venous outflow stenotic lesions caused by endothelial and fibromuscular hyperplasia.^{13,66,103,119,125} Few studies comparing venous stenoses correction with PTA versus surgical revision have been performed, and they report conflicting results.^{172,173} Published non-comparative data do not indicate a preferred technique for the treatment of access stenosis.^{13,38,53,66,103,111,112,119,174-178}

The potential long-term patency rate following PTA is well established.^{103,111,112,119,174-177} Published series consistently report 40% to 50% 6-month unassisted patency rates from PTA. Long-term unassisted patency after surgical revision is less well established due to reporting of cumulative patency.^{13,38,66} The Work Group believes that a 50% 1-year unassisted patency after

*Unassisted patency is defined as patency until either a thrombosis or access failure or an intervention to prevent thrombosis is performed.

surgical revision should be the goal. Treatment of stenoses postthrombosis yields lower primary patency rates than elective correction of stenoses detected by monitoring. This observation suggests that thromboses are associated with more critical stenoses¹⁶⁶ (see Guideline 21: Treatment of Thrombosis and Associated Stenosis in Dialysis AV Grafts).

Surgical revision is held to a higher standard than PTA because surgical revision usually extends the access farther up the extremity by the use of a jump graft. Thus, more vein is used in surgical revision than in PTA.

Individual patients may have rapid recurrence of stenosis that requires repeated PTA.^{103,111} In these patients, repeated PTA may not be cost-effective, prompting surgical revision. The Work Group recommends defining PTA failure as the need for more than two PTA interventions within a 3-month interval.¹⁷⁷

The unassisted patency of stents in hemodialysis access is no better than that following PTA, except in elastic stenoses.^{36,179-183} Thus, stents should be reserved for surgically inaccessible stenoses that fail PTA.

Arterial inflow stenoses are relatively uncommon.^{9,103,109,119} They usually manifest themselves as an inability to achieve target blood flow due to increased negative arterial pre-pump pressure.

GUIDELINE 20

Treatment of Central Vein Stenosis

Percutaneous intervention with transluminal angioplasty is the preferred treatment for central vein stenosis.

Stent placement combined with angioplasty is indicated in elastic central vein stenoses or if a stenosis recurs within a 3-month period. (**Evidence**)

Rationale Early detection and treatment of central vein stenosis reduces the rate of thrombosis and increases the likelihood of preserving an existing extremity for future access.^{9,109,119,163,179} Surgical treatment of central vein stenosis requires thoracotomy and should be avoided. Stents improve patency in subclasses of patients with elastic stenoses and in patients with early recurrence of stenoses.^{15,20,103,112,179,180,183}

GUIDELINE 21

Treatment of Thrombosis and Associated Stenosis in Dialysis AV Grafts

Thrombosis Treatment Thrombosis of an AV graft should be corrected with surgical thrombectomy or with pharmacomechanical or mechanical thrombolysis. The choice of technique to treat thrombosis should be based on the expertise of the center. However, it is essential that:

- A. Treatment be performed rapidly following detection of thrombosis to minimize the need for temporary access. (No more than one, and preferably, no femoral vein catheterization should be required.) (**Opinion**)
- B. The access be evaluated by fistulogram for residual stenosis postprocedure. (**Evidence**)
- C. Residual stenosis be corrected by angioplasty or surgical correction. (**Evidence**) (Note: Outflow venous stenoses are present in >85% of instances of thrombosis; the need for PTA or surgical revision is expected in most instances.)
- D. The procedure be performed as outpatient procedure under local anesthesia. (Access revision may require up to a 24-hour observation to evaluate swelling and steal.) (**Opinion**)
- E. Monitoring tests used to screen for venous obstruction should return to normal following intervention (see Guidelines 10, 17, and 18). (**Evidence**)

Patency goals following thrombosis. Centers should monitor outcome results on the basis of patency; minimum reasonable goals (for the center as a whole) for percutaneous thrombolysis and surgical revision thrombectomy should be:

Percutaneous thrombolysis with PTA: 40% unassisted patency and functionality at 3 months (**Evidence**)

Surgical thrombectomy and revision: 50% unassisted patency and functionality at 6 months and 40% unassisted patency and functionality at 1 year (**Opinion**)

Immediate patency*: 85% for both techniques (**Evidence/Opinion**)

*Immediate patency is defined as patency to next hemodialysis session.

Rationale Available data do not indicate a clear-cut preference between surgical thrombectomy and revision and percutaneous mechanical or pharmacomechanical thrombolysis. Comparative studies^{163,164,184-186} show conflicting results, with similar technical success rates and long-term patencies between these methodologies. Noncomparative studies do not yield a definitive preference.^{13,14,38,53,66,103,158-162,178,187,188} In the Work Group's opinion, current data suggest surgical thrombectomy and mechanical and pharmacomechanical thrombolysis are all effective for resolving thrombosis.

Thrombosis is associated with underlying venous stenosis in >85% of instances.^{13,14,38,66,158-162,178,187} It is essential that fistulography is performed rapidly to prove the stenosis is corrected. Failure to do so will result in rapid repeat thrombosis.^{13,66}

Delay in restoring access will result in the need for temporary catheters. The Work Group's consensus is that the placement of more than one temporary femoral catheter while awaiting thrombosis correction is unwarranted. Placement of a central vein catheter while awaiting thrombosis treatment is also unwarranted.

General anesthesia and hospitalization add to the risk and cost of treatment respectively and should be avoided when possible.

Patency rates. Stenosis accompanied by thromboses are more difficult to treat than stenoses detected by prospective monitoring; treatment of stenoses associated with thrombosis is therefore associated with poorer outcomes for both surgical and percutaneous techniques. Percutaneous techniques yield 90-day patencies ranging from 30% to 40%; 40% is an acceptable goal.^{160-162,187} Surgical unassisted patency is difficult to determine due to reporting of cumulative patencies; it is approximately 50% at 6 months and 20% at 1 year.^{164,185,186} The Work Group recommends goals of 50% unassisted patency at 6 months and 40% unassisted patency at 1 year.^{13,14} Surgical correction of stenoses is held to a higher standard than PTA because the access is usually extended farther up the extremity when surgical revision is performed.

GUIDELINE 22

Treatment of Thrombosis in Primary AV Fistulae

Thrombosis of an AV fistula is difficult to treat. Neither percutaneous nor surgical techniques offer good results. Each institution should attempt to resolve thrombosis with the technique that is preferred at that institution. **(Opinion)**

Rationale Little data on the success of treating thrombosis in native AV fistulae are reported. The Work Group believes that treatment of thrombosis in native AV fistulae is not as successful as treatment of thrombosis in AV grafts. Some authors have reported success with various techniques.¹⁸⁹

GUIDELINE 23

Treatment of Tunneled Cuffed Catheter Dysfunction

Catheter dysfunction is defined as failure to attain and maintain an extracorporeal blood flow sufficient to perform hemodialysis without significantly lengthening the hemodialysis treatment. The Work Group considered sufficient extracorporeal blood flow to be 300 mL/min. **(Opinion)**

Urokinase is currently not available on the US market. Preliminary studies using thromboplastin activator (TPA) and recombinant urokinase (rUK) in the treatment of hemodialysis catheter dysfunction are underway and appear promising. At this time neither agent has sufficient evidence for the guidelines to recommend their wholesale adoption.

- A. A dysfunctional catheter should be treated in the hemodialysis unit using the protocol for intraluminal urokinase administration (see Table III-2 in Guideline 6: Acute Hemodialysis Vascular Access—Non-cuffed Catheters). **(Evidence)**
- B. If urokinase treatment fails, a radiographic study using catheter contrast injection should be performed. Further treatment should then be performed based on the radiographic findings. Appropriate treatments include:
 1. Fibrin sheath stripping using a snare if a fibrin sheath is present **(Evidence)**
 2. Exchanging the thrombosed catheter over a guidewire if a fibrin sheath is

present or if the catheter is malpositioned or of inadequate length (**Evidence**)

3. Intra-catheter urokinase infusion (eg, 20,000 units/lumen/hour) for 6 hours if a fibrin sheath is present or a luminal thrombosis remains (**Evidence**)
4. Performing embolectomy on the catheter if the lumens show residual thrombus (**Opinion**)
5. Repositioning a malpositioned catheter using a snare (**Evidence**)

Rationale Thrombosis of catheter lumens is the most common cause of catheter dysfunction.^{73,128} The urokinase protocol^{78,128} (see Table III-2, Guideline 6) is successful in resolving the thrombus in 70% to 90% of instances.¹²⁸ This protocol should be attempted as the first procedure to resolve catheter thrombosis because it is the least invasive and least costly of all catheter salvage techniques.

Catheter imaging with contrast infusion will identify other correctable problems (residual lumen thrombus, external fibrin catheter sheath, malpositioned catheter tip). Treatment of fibrin sheath formation may include fibrin sheath stripping, guidewire catheter exchange, and urokinase infusion.^{78,79,190} Any of the three techniques are acceptable options for correcting fibrin sheath adherence to cuffed catheters.

Intraluminal residual thrombosis may be treated with urokinase infusion or with catheter embolectomy. The Work Group concluded that both procedures are effective for treating intra-catheter thrombosis that does not respond to the urokinase protocol.

Catheter malposition may be corrected by snare-mediated catheter repositioning or by exchange of the catheter over a guidewire.^{78,79} The Work Group's opinion is that both methods are effective. Catheters of inadequate length should be exchanged over a guidewire to the appropriate position or replaced.

Additional data are emerging on the role of continuous thrombolytic therapy, as opposed to mechanical therapy, in the treatment of malfunctioning catheters. Preliminary evidence suggests that continuous three hour infusion of 250,000 units during the dialysis treatment may also be effective treatment of fibrin sheath. Further stud-

ies of the use of continuous urokinase infusions are pending. Currently urokinase (Abbott) is not available on the North American market. Preliminary studies utilizing recombinant urokinase and thromboplastin activator TPA are underway.

GUIDELINE 24

Treatment of Infection of Dialysis AV Grafts

Local infection of a dialysis AV graft should be treated with appropriate antibiotics based on culture results and by incision/resection of the infected portion of the graft. (**Evidence**)

Extensive infection of a dialysis AV graft should be treated with antibiotics and total resection of the graft. (**Evidence**)

Infection of a newly placed graft (ie, within 1 month) should be treated with antibiotics and by removing the graft, regardless of the extent of the infection. (**Opinion**)

Initial antibiotic treatment should cover both Gram-negative and Gram-positive organisms and should cover *Enterococcus*. (**Opinion**)

Rationale Infection involving an AV graft has been demonstrated to require both antibiotic therapy and surgical therapy to achieve cure in the vast majority of cases.^{14,191,192} Superficial infection that does not involve the graft may respond to antibiotic therapy alone. Antibiotic therapy should be based on culture results but initially should include both Gram-negative and staphylococcal and streptococcal coverage because of the likelihood of both Gram-negative and Gram-positive infection. An increasing trend toward enterococcal infection warrants coverage of this organism until culture results are obtained.

A newly placed graft is not incorporated into the surrounding tissue; thus, in the Work Group's opinion, even a localized infection of a new graft requires total removal of the graft. (For management of established AV grafts that are infected, see Guideline 17: When to Intervene Dialysis AV Grafts for Venous Stenosis, Infection, Graft Degeneration, and Pseudoaneurysm Formation.)

GUIDELINE 25

Treatment of Infection of Primary AV Fistulae

Infections of primary AV fistulae are rare and should be treated as subacute bacterial endocarditis with 6 weeks of antibiotic therapy. Fistula

take-down is required in cases of septic emboli. **(Opinion)**

Rationale Native AV fistulae infections have been shown to respond well to antibiotic therapy without fistula removal in most instances. The Work Group believes only septic emboli warrant take-down of the fistula.

GUIDELINE 26

Treatment of Infection of Tunneled Cuffed Catheters

Tunneled cuffed catheter infection is a serious problem. Appropriate treatment is dependent upon the nature of the infection:

- A. Catheter exit site infections—characterized by redness, crusting, and exudate at the exit site in the absence of systemic symptoms and negative blood cultures—should be treated as follows:
 1. Apply topical antibiotics, ensuring proper local exit site care; do not remove the catheter. **(Opinion)**
 2. If there is tunnel drainage, treat with parenteral antibiotics (anti-staphylococcal, anti-streptococcal therapy pending exit site cultures) in addition to following appropriate local measures. Definitive therapy should be based on culture results. Do not remove the catheter unless the infection fails to respond to therapy. If the infection fails to respond to therapy, remove the catheter and replace it using a different tunnel and exit site. **(Evidence/Opinion)**
- B. Catheter-related bacteremia, with or without systemic signs or symptoms of illness, should be treated by initiating parenteral treatment with an antibiotic(s) appropriate for the organism(s) suspected, usually *Staphylococcus* and *Streptococcus*. **(Evidence)** Definitive therapy should be based on the organism(s) isolated. **(Evidence)** The catheter should be removed in all instances if the patient remains symptomatic more than 36 hours. **(Evidence)** The catheter should also be removed in any clinically unstable patient. **(Opinion)** Preliminary reports suggest that after obtaining a bactericidal level of the antibiotic in the blood, in a stable asymptomatic patient

without exit site or catheter tunnel tract involvement may be treated by changing the catheter over a guidewire plus a minimum of 3 weeks of systemic antibiotic therapy. Blood cultures should be repeated periodically during and immediately after this treatment to monitor its effectiveness.

A new permanent access should not be placed until blood cultures, performed after cessation of antibiotic treatment, have been negative for at least 48 hours. **(Opinion)**

Rationale Infection is one of the leading causes of catheter removal and morbidity in dialysis patients.^{70,78,153} Catheters associated with exit site infections alone can usually be salvaged without the need for catheter replacement.^{70,71,73} Catheter-mediated bacteremia is the major reason for catheter loss⁷⁸ and has been associated with substantial morbidity, including metastatic infection.⁸¹ Catheter-mediated bacteremia is a life-threatening condition requiring initial hospitalization and parenteral antibiotic therapy. Unstable patients require removal of the catheter for rapid response to therapy. Despite initial reports of success (catheter salvage) with an “antibiotic lock” technique¹⁹³ in a recent large trial of patients with catheter-mediated bacteremia, systemic antibiotics alone were able to salvage less than 25% of catheters.¹⁵³ Most infections recurred as soon as the antibiotics were discontinued. In contrast, a preliminary study using catheter guidewire exchange in stable patients without tunnel involvement was able to salvage most catheters without apparent ill effects.⁸⁰ Bacteremia with tunnel tract involvement should prompt catheter removal. The Work Group believes that 3 weeks of systemic antibiotic therapy are needed to treat catheter-associated bacteremia and that new permanent access should not be placed until cultures have been negative for at least 48 hours after cessation of antibiotic therapy.

GUIDELINE 27

Treatment of Pseudoaneurysm of Dialysis AV Grafts

Needle insertion into the area of pseudoaneurysm should be avoided. **(Opinion)**

Pseudoaneurysm of a dialysis AV graft should be treated by resection and insertion of an interposition graft if the pseudoaneurysm:

- A. Is characterized by rapid expansion in size (**Evidence/Opinion**)
- B. Exceeds twice the diameter of the graft (**Opinion**)
- C. Threatens viability of the overlying skin (**Opinion**)
- D. Is infected (**Evidence**)

Rationale Insertion of needles into a pseudoaneurysm may result in hemorrhage and should be avoided. A pseudoaneurysm is most effectively treated by resection and segment interposition.^{53,169} Pseudoaneurysms that are not resected may expand and rupture, resulting in significant blood loss. Pseudoaneurysms that exceed twice the diameter of the graft or those that are increasing in size should be surgically corrected due to their increased risk of rupture. Pseudoaneurysm

expansion that threatens the viability of the skin places the patient at risk of graft infection. In these cases, surgical correction is indicated.

GUIDELINE 28

Aneurysm of Primary AV Fistulae

Aneurysms of primary AV fistulae require surgical intervention only when the aneurysm involves the arterial anastomosis. Venipuncture should avoid the aneurysm. (**Opinion**)

Rationale Aneurysms develop as a matter of course in AV fistulae. Their natural history is benign. The Work Group recommends revision only if the aneurysm involves and compromises the arterial anastomosis. Venipuncture should avoid the aneurysm due to the risk of difficult hemostasis in the area of the aneurysm.

VI. Potential Quality of Care Standards

BACKGROUND

Hemodialysis access failure is a major cause of morbidity for patients on hemodialysis. A high percentage of hospitalizations in these patients is due to vascular access complications.^{9-11,194} Results appear to be worsening, since the interval between access placement and the need for a procedure to restore access patency has been decreasing.^{7,10} In addition, expenditures for reconstituting patency are substantial and increasing.^{7,10}

To reverse these trends, dialysis centers should:

- A. Institute monitoring programs to detect vascular accesses at risk.
- B. Establish quality assurance programs that track access complication rates and outcomes.
- C. Develop methods that extend access use-life.

Access use-life can be extended by:

- A. Increasing the percentage of patients with native or primary AV fistulae through:
 - 1. Early identification and referral of patients with progressive kidney disease to nephrologists—allowing access construction well in advance of the need for hemodialysis (**Evidence**)
 - 2. Re-evaluation for a native AV fistula after every access failure (**Opinion**)
- B. Periodic monitoring of accesses to detect hemodynamically significant stenoses prior to thrombosis (**Evidence**)
- C. Expedient referral of patients for appropriate angioplasty or surgical revision following the detection of stenoses (**Evidence**)
- D. Implementing staff and patient education programs on the importance and care of vascular access (**Opinion**)

GUIDELINE 29

Goals of Access Placement—Maximizing Primary AV Fistulae

- A. Primary AV fistulae should be constructed in at least 50% of all new kidney failure patients electing to receive hemodialysis as their initial form of renal replacement therapy. Ultimately, 40% of prevalent pa-

tients should have a native AV fistula (see Guideline 3: Selection of Permanent Vascular Access and Order of Preference for Placement of AV Fistulae.) (**Opinion**)

- B. Patients should be re-evaluated for possible construction of a primary AV fistula after failure of every dialysis AV access. (**Opinion**)
- C. Each center should establish a database to track the types of accesses created and the complication rates. (**Opinion**)

Rationale A primary AV fistula using the cephalic vein confers the best permanent access with the fewest complications^{13,38,40,41,195} (see Guideline 3: Selection of Permanent Vascular Access and Order of Preference for Placement of AV Fistulae). Native accesses have the best 4- to 5-year patency rates and require fewer interventions compared to other access types.^{3,4} The frequency of primary AV fistula construction in the US is unjustifiably low (less than 30% to total access placements)¹⁹⁴ compared to Europe or Canada (with frequencies of more than 50% of total access placements),^{3,196} even after adjustments are made for demographic differences that may influence choice of access type. An increase in the percentage of native AV fistulae is best accomplished by early determination of the patient's preferred dialysis modality while dialysis initiation is still months away, since primary AV fistulae ideally should be allowed to mature 3 to 4 months before use. In many patients, a previous native or synthetic access produces dilatation of arm veins, permitting construction of a new primary AV access at a site not previously available. AV fistula constructions that use the brachial artery can produce long-lasting access.^{41,44,46,47,195} Time-urgency for initiating hemodialysis does not justify substitution of a synthetic dialysis AV graft in patients starting hemodialysis or in patients with failed previous accesses because, in either case, cuffed catheters are an effective means of bridging the longer time necessary for primary AV fistula maturation.^{70,72,75,197}

Each center should develop an access database in order to identify problems in access creation and maintenance.

GUIDELINE 30**Goals of Access Placement—Use of Catheters for Chronic Dialysis**

- A. Less than 10% of chronic maintenance hemodialysis patients should be maintained on catheters as their permanent chronic dialysis access. In this context, chronic catheter access is defined as the use of a dialysis catheter for more than 3 months in the absence of a maturing permanent access. **(Opinion)**
- B. ESRD patients should be educated on the risks and benefits associated with catheters and strongly encouraged to allow the creation of an AV fistula for permanent access where appropriate. **(Opinion)**

Rationale The use of cuffed dialysis catheters for long-term access is associated with a dramatic increase in access complications:

- A. Cuffed catheters are associated with lower blood flow rates compared to AV access.^{72,84,93,197} As a result, catheters used long-term without appropriate adjustments in treatment duration can compromise dialysis adequacy.¹⁹⁸ Compromise of dialysis adequacy is associated with increased morbidity and mortality.
- B. Systemic and local infections occur more frequently with cuffed catheters^{75,78,93,139,153,197,199-201} than with AV accesses.¹³⁶
- C. Chronic catheter access is associated with a risk of central venous stenosis.^{20,26,102} Development of central vein stenosis can preclude the establishment of a permanent vascular access for hemodialysis.
- D. The initial success, ease-of-use, and painless access to the patient's blood offered with a dialysis catheter may foster reluctance in the patient to consider other more permanent access options, despite the greater risk of infection and inadequate dialysis associated with chronic permanent catheter access use. Patients should be educated on these issues and strongly encouraged to allow creation of an AV fistula for permanent access where appropriate.

GUIDELINE 31**Center-Specific Thrombosis Rate**

- A. The rate of graft thrombosis should not exceed 0.5 thrombotic episodes per patient year at risk. **(Evidence/Opinion)**
- B. After adjusting for initial failures (ie, failures within the first 2 months of fistula use), the rate of thrombosis of native AV fistulae should be less than 0.25 episodes per patient year at risk. **(Opinion)**
- C. Dialysis centers should examine their thrombosis rates and the underlying causes as part of an ongoing QA/CQI program. **(Opinion)**

Rationale The current national average rate of thrombosis of dialysis AV grafts is unknown, but is likely to be higher than the overall rate (all permanent accesses) of approximately 0.8 episodes per patient year at risk,^{9,119} since these results included all types of permanent AV access. Some centers have reported much higher thrombosis rates,^{29,164} but such rates are quite sensitive to the mix of native and prosthetic grafts in the dialysis center and vascular comorbidity. The rate of thrombosis is largely determined by the presence of unrecognized hemodynamically significant stenosis.^{29,114,160,161,163,202} Early detection and treatment of stenosis reduces the frequency of thrombosis^{9,29,119,203} and reduces access replacement rates by up to 70%.^{9,119} Dialysis AV grafts should be monitored to permit early detection of hemodynamically significant stenosis with the goal of reducing the thrombosis rate to a maximum of 0.5 thrombosis per year for AV grafts. Based on intervention studies,^{9,119} this thrombosis rate is achievable. By detecting and treating stenoses early in patients with synthetic grafts, as outlined in this set of guidelines, the Work Group believes that the rate of graft thrombosis can be reduced significantly.

Native accesses have a much lower thrombosis rate compared to prosthetic grafts.⁴ Sequential measurements of flow can detect deterioration of native access function.¹⁶⁵ All of these strategies should reduce the risk of thrombotic failure. The Work Group concluded that a thrombosis rate of 0.25 episodes per patient year in native fistulae is achievable.

GUIDELINE 32**Infection Rate**

The rate of infection should not exceed 1% in primary AV fistulae and should not exceed 10% in dialysis AV grafts, both calculated over the use-life of the access. (**Opinion**)

For tunneled cuffed catheters, the recommended target rate of systemic infection is less than 10% at 3 months and less than 50% at 1 year. (**Opinion**)

Rationale Infectious complications of accesses are a leading cause of morbidity and mortality in dialysis patients.¹⁹⁴ The current national combined infection rates for permanent accesses, for local and bacteremic infections, are 1% to 4% for primary AV fistulae^{40,41,47} and 11% to 20% for AV grafts.^{14,40,51,53,58,192,204}

The catheter infection rate is highly variable^{151,190} and clearly depends on the duration of use.^{78,99,153} At 2 weeks of catheterization, the incidence of infection of noncuffed central catheters is generally under 8%.²⁰⁵ Suchoki et al⁷⁸ reported a <5% bacteremia rate in cuffed catheters used <3 months. In contrast, a 50% removal rate for infection was reported for cuffed catheters at 12 months of use.⁷⁸

The Work Group's recommendations are significantly lower than the published experiences of various centers. The Work Group believes infection rates can be significantly lowered through meticulous attention to detail, and in the case of catheters, following the recommendations in Guideline 15: Catheter Care and Accessing the Patient's Circulation, on skin preparation at the time of placement,²⁰⁶ topical antibiotics,^{150,151} and the use of non-occlusive dressings.¹⁴⁹ Programs with high infection rates should consider the importance of nurse and patient training¹⁴⁰ (see Guideline 13: Infection Control Measures).

GUIDELINE 33**Primary Access Failure Rate—AV Grafts**

The primary access failure rates of virgin dialysis AV grafts in the following locations and configurations should not be more than: (**Evidence/Opinion**)

- Forearm straight grafts: 15%
- Forearm loop grafts: 10%
- Upper arm grafts: 5%

By proposing these goals for 30-day primary failure rates for various graft configurations, the Work Group does not wish to imply that upper arm grafts should be elected over forearm grafts solely on the basis of these recommended primary failure rates. Indeed, the Work Group encourages the creation and maintenance of access sites as distally as possible to preserve more proximal veins for future access options.

Each center should monitor its performance to identify problems in access construction and use. (**Opinion**)

Rationale Primary access failure is considered failure of patency within the first 30 days after placement. Primary failure of dialysis AV grafts is caused by technical problems. It is the Work Group's opinion that the primary failure rate reflects a center effect that is influenced by surgical access construction, patient demographics, comorbidity, and graft loss due to premature cannulation and hematoma formation. Primary failure rates of dialysis AV grafts at the same anatomical sites vary depending on whether the grafts are the primary, secondary, or tertiary access. The rates provided are derived from the published literature for first graft accesses constructed in a general hemodialysis population.^{13,14,38,40,51,53} Failure of a dialysis AV graft prior to use reflects surgical construction problems. Prosthetic bridge graft survival is decreased in diabetics, even at 30 days, and may be affected adversely by increasing age in non-diabetics.¹⁹⁸ Patient demographics, characteristics, and comorbidity may differ across centers and explain some of the center effect. Each center should monitor its performance, recognizing the influence of some demographic factors, but tracking its own problems in access construction and use. Marked deviations from the recommended patency rate should invoke a multidisciplinary evaluation of possible factors and their modification.

GUIDELINE 34**Primary Access Failure Rate—Tunneled Cuffed Catheters**

The primary failure rate of catheters refers to the fraction of catheters that are unable to deliver

adequate blood flow (>300 mL/min) during the first attempted dialysis treatment.

The primary failure rate of tunneled cuffed catheters should be no more than 5%. The cumulative incidence of the following insertion complications should not exceed 2% of all catheter placements: **(Evidence)**

- A. Pneumothorax requiring a chest tube
- B. Symptomatic air embolism
- C. Hemothorax
- D. Hemomediastinum
- E. Hematoma requiring evacuation

Rationale Complications related to the insertion of tunneled cuffed catheters depend on operator skill. Cuffed catheters can be inserted with reference to anatomical landmarks, with or without ultrasound,^{190,207} but always with the use of fluoroscopy to verify proper positioning of the catheter tip. Cuffed catheters can be placed by nephrologists, surgeons, or radiologists.¹⁹⁰ Cumulative complication rates of less than 5% are routinely obtained.^{73,190} A recommended complication rate of less than 2% is lower than values reported in the literature. However, the published results are based on procedures obtained without benefit of ultrasound guidance. In the Work Group's opinion, rates of 2% are obtainable in many centers and should be the goal.

GUIDELINE 35

Primary Access Failure—Native AV Fistulae

No guideline for primary access failure is recommended. **(Opinion)**

Rationale To achieve the proposed goal of attaining native AV fistulae in at least 40% of patients requiring dialysis access (see Guideline 29: Goals of Access Placement—Maximizing Primary AV Fistulae), the Work Group recommends that the primary failure rate of AV fistulae not be used as an indicator of quality. To do otherwise might discourage native fistulae construction in patients with more complex vascular anatomy (ie, in patients who are at a higher risk for failure). Nevertheless, primary failure of native AV fistulae should be examined in dialysis centers as part of their QA/CQI vascular access programs.

GUIDELINE 36

Cumulative Patency Rate of Dialysis AV Grafts

The cumulative patency rate of dialysis AV grafts refers to the number of grafts that remain patent (regardless of the number of primary interventions and/or thrombectomies) during the given time period.

The cumulative patency rate of all dialysis AV grafts should be at least 70% at 1 year, 60% at 2 years, and 50% at 3 years. **(Evidence/Opinion)**

Rationale Numerous investigators report 1-year patency rates of AV grafts between 63% and 90%.^{13,14,38,184} Mehta reports an overall average patency rate of 70%.⁴ Many investigators have reported patency rates at 2 and 3 years as well.^{13,14,38,43} Outflow obstruction, followed by thrombosis, accounts for the majority of AV graft failures. The Work Group believes that prospective monitoring (see Guideline 10: Monitoring Dialysis AV Grafts for Stenosis, and Guideline 11: Monitoring Primary AV Fistulae for Stenosis) can improve this reported experience despite the aging of the population and the increasing percentage of patients with diabetes or peripheral vascular disease. Thus, the cumulative patency targets for AV grafts of 70% at 1 year, 60% at 2 years, and 50% at 3 years should be achievable.

GUIDELINE 37

Cumulative Patency Rate of Tunneled Cuffed Catheters

Because of variations in catheter use and design, the Work Group believes that it cannot make a reasonable estimate of expected cumulative patency of dialysis catheters at this time. The use of cuffed catheters as permanent vascular access should be discouraged except in particular patient groups (see Guideline 3: Selection of Permanent Vascular Access and Order of Preference for Placement of AV Fistulae). **(Evidence/Opinion)**

Rationale Intravenous double-lumen cuffed catheters are used both as temporary access while a permanent access is maturing and as permanent access in patients who have exhausted other options. This variation in intended use creates significant variation in catheter survival rates.

Moss reported a median cumulative catheter survival rate of 18.5 months; 65% of silicone dual-lumen catheters survived 1 year.⁷³ By contrast, Lund et al¹⁹⁰ reported a 1-year cumulative patency of 30%. Canaud et al,⁷⁴ using two single-lumen silastic catheters (with the majority serving to bridge a period until permanent access was established), reported an average catheter survival of 57 days. Suchoki et al⁷⁸ reported a 50% catheter survival rate at 12.7 months.

The Work Group discourages the use of cuffed catheters as permanent vascular access because of their increased complication rates. The primary reason for cuffed catheter loss is infection.⁷⁸

GUIDELINE 38

Cumulative Patency Rate of Primary AV Fistulae

No guideline for cumulative access patency is recommended. (**Opinion**)

Rationale To achieve the proposed goal of attaining native AV fistulae in at least 40% of patients requiring dialysis access, the Work Group recommends that the cumulative patency rate of AV fistulae not be used as an indicator of quality. To do otherwise might discourage native fistulae construction in patients with more complex vascular anatomy who may be at a higher risk for failure. Nevertheless, cumulative patency rates should be examined in dialysis centers as part of their QA/CQI vascular access programs.

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VIII. Biographical Sketches of the NKF-K/DOQI Vascular Access Work Group Members

The following are brief sketches that describe the professional training, experience, and principal business affiliations of the Work Group members. All Work Group members completed a disclosure statement certifying that any potential conflict of interest would not influence their judgment or actions concerning the NKF-DOQI.

Steve Schwab, MD (Work Group Chair), is Professor and Vice Chairman of Medicine and Co-Chief for the Division of Nephrology at the Duke University Medical Center; He also serves as Chief, Section of Hospital Medicine. Dr. Schwab serves on multiple editorial boards. Dr. Schwab is a member of the American Board of Internal Medicine Subspecialty Board for Nephrology and also serves on the American Society of Nephrology's Clinical Research Committee. He is the author of more than 100 articles and chapters dealing with issues in nephrology and end-stage renal disease. Dr. Schwab reported receiving grant funding from the NIH and Amgen Inc. He serves on medical advisory boards for Gambro, VascA Inc., and Amgen Inc.

Anatole Besarab, MD, FACP (Work Group Vice-Chair), is Chief, Section of Nephrology, West Virginia University School of Medicine. Dr. Besarab has been a practicing nephrologist for 25 years. In the past decade, his work in ESRD has focused on optimizing the management of anemia and detecting vascular access dysfunction prior to thrombosis. He has been a consultant to industry and has served on local and national committees. Dr. Besarab has published more than 100 articles, ranging from basic science to clinical practice, and his work has been presented at most of the national and international nephrology society meetings. He has been on the editorial board of several journals and has been active in many societies. His current research interests include evaluation of diagnostic tests to detect angioaccess dysfunction and developing algorithms which maximize hematopoietic response to recombinant human erythropoietin. Dr. Besarab reported affiliations with Amgen Inc. and Schein Pharmaceuticals.

Gerald Beathard, MD, PhD, FACP, is a member of Capital Nephrology Associates of Austin, Texas. He practices nephrology on a half

time basis. His practice is primarily limited to Interventional Nephrology. He is also the Medical Director of U.S. Vascular Access Centers. Dr. Beathard has been actively involved with the endovascular treatment of dialysis access dysfunction since 1987 and has extensive experience in these procedures. He is the Medical Director of Nephrology Vascular Laboratory at St. David's Hospital in Austin, Texas. He has published articles dealing with all aspects of dialysis vascular access and has been involved in workshops dealing with this area for several years. Dr. Beathard has been active in the practice of nephrology for 32 years. He is on the Editorial Boards of several journals. He holds appointments to the faculty at LSU Medical School in Shreveport, Louisiana, the University of Texas Health Science Center in Houston, Texas and the University of Texas medical Branch, Galveston, Texas.

Deborah Brouwer, RN, CNN, is a nephrology nurse with 17 years of clinical experience in all forms of renal replacement therapies. She has worked as an acute and chronic dialysis staff nurse, nursing supervisor, staff education coordinator, CQI Coordinator and a Clinical Support Specialist. Currently she is the Education and Development Specialist for the Division of Nephrology and Hypertension at Allegheny General Hospital in Pittsburgh, PA. Ms. Brouwer has published on the topic of vascular access nursing care issues. She enjoys lecturing about nursing issues involving vascular access at professional meetings around the country. She is an active volunteer with the NKF on the Public Education Committee and serves as the Nursing editor of the Family Focus Newsletter. She is an active member of the local ANNA Three River's chapter.

Michael Levine, MD, is the Director of the Arteriovenous Hemodialysis Access Maintenance Program, Section of Interventional Nephrology, for Milwaukee Nephrologists, a private nephrology practice in Milwaukee, Wisconsin. A board certified nephrologist, for the last seven years Dr. Levine's clinical practice has been dedicated to vascular access monitoring and percutaneous access salvage utilizing balloon angioplasty and mechanical thrombectomy.

Dr. Levine oversees the care of the arteriovenous dialysis accesses for 400 hemodialysis patients, and in doing so, has performed approximately 700 percutaneous interventions on AV grafts and fistulae over the previous three years. His current areas of interest are the prevention of access thrombosis based on monthly intra-access flow measurements, developing strategies to increase the prevalence of native AV fistulae in the United States, percutaneous salvage of the failing to mature AV fistula, and methods, in addition to angiography, for accurately assessing the success of an intervention during the actual procedure. Dr. Levine is a member of the International Vascular Access Society, gives lectures on dialysis vascular access in the United States and abroad, and trained nephrologists from around the country in interventional techniques. While working on K/DOQI, Dr. Levine was a member of the Division of Nephrology and Hypertension at Beth Israel Medical Center in New York City.

Richard McCann, MD, FACS, is Professor of Surgery and Chief of the Vascular Surgery service at Duke University Medical Center in Durham, North Carolina. Dr. McCann trained in general and vascular surgery at Duke from 1974-1983 and was appointed to the faculty following his residency. He has been active in vascular surgery, vascular access surgery, and kidney transplantation for more than 10 years. He has published 91 articles in peer-reviewed journals dealing with vascular surgery and vascular access. Dr. McCann is a member of the American Society of Transplant Surgeons, the American Surgical Society, the Southern Surgical Association, the Southern Association for Vascular Surgery, and the Society for Vascular Surgery.

Richard Sherman, MD, is the Medical Director of ESRD Services and Professor of Medicine at the University of Medicine and Dentistry of New Jersey, Robert Wood Johnson Medical School. He was Medical Director of Dialysis at Robert Wood Johnson University Hospital in New Brunswick, New Jersey for 18 years and at the Dialysis Clinics, Inc., North Brunswick, New Jersey for 5 years. He founded and edits the bimonthly journal *Seminars in Dialysis*. Dr. Sherman has published more than 100 articles and, in recent years, has had particular interest in improving the evaluation of vascular access for hemodialysis. He is a member of the speakers program for Amgen, Inc. and Ortho Biotech, Inc. and serves as a consultant to Aksys, Ltd. Dr. Sherman reported receiving grant funding from Baxter Healthcare and R & D Laboratories.

Scott Trerotola, MD, is the Director of Vascular and Interventional Radiology and Professor of Radiology at Indiana University School of Medicine. Dr. Trerotola has had an active interest in hemodialysis access for more than 10 years and has published over 100 articles in peer-reviewed journals, many describing the role of interventional radiology in hemodialysis access. His current research centers on the role of mechanical thrombolysis and stents in hemodialysis access, and he is a strong advocate of the physical examination of access sites. Dr. Trerotola is active in several professional societies and is on the editorial board of four radiology journals. He holds four US patents and is the inventor of the Arrow-Trerotola Percutaneous Thrombolytic Device, widely used in the percutaneous treatment of thrombosed hemodialysis access grafts.