I. CLINICAL PRACTICE GUIDELINES FOR VASCULAR ACCESS

GUIDELINE 2. SELECTION AND PLACEMENT OF HEMODIALYSIS ACCESS

A structured approach to the type and location of long-term HD accesses should help optimize access survival and minimize complications.

The access should be placed distally and in the upper extremities whenever possible. Options for fistula placement should be considered first, followed by prosthetic grafts if fistula placement is not possible. Catheters should be avoided for HD and used only when other options listed are not available.

2.1 The order of preference for placement of fistulae in patients with kidney failure who choose HD as their initial mode of KRT should be (in descending order of preference):

- 2.1.1 Preferred: Fistulae. (B)
  - 2.1.1.1 A wrist (radiocephalic) primary fistula. (A)
  - 2.1.1.2 An elbow (brachiocephalic) primary fistula. (A)
  - 2.1.1.3 A transposed brachial basilic vein fistula: (B)
• 2.1.2 Acceptable: AVG of synthetic or biological material, such as: (B)
  o 2.1.2.1 A forearm loop graft, preferable to a straight configuration.
  o 2.1.2.2 Upper-arm graft.
  o 2.1.2.3 Chest wall or “necklace” prosthetic graft or lower-extremity fistula or graft; all upper-arm sites should be exhausted.
• 2.1.3 Avoid if possible: Long-term catheters. (B)
  o 2.1.3.1 Short-term catheters should be used for acute dialysis and for a limited duration in hospitalized patients. Noncuffed femoral catheters should be used in bed-bound patients only. (B)
  o 2.1.3.2 Long-term catheters or dialysis port catheter systems should be used in conjunction with a plan for permanent access. Catheters capable of rapid flow rates are preferred. Catheter choice should be based on local experience, goals for use, and cost. (B)
  o 2.1.3.3 Long-term catheters should not be placed on the same side as a maturing AV access, if possible. (B) Special attention should be paid to consideration of avoiding femoral catheter access in HD patients who are current or future kidney transplant candidates. MRA imaging of both arteries and veins is the diagnostic procedure of choice for evaluating central vessels for possible chest wall construction.
• 2.1.4 Patients should be considered for construction of a primary fistula after failure of every dialysis AV access. (B)
• 2.1.5 While this order of access preference is similar for pediatric patients, special considerations exist that should guide the choice of access for children receiving HD. Please refer to CPG 9 for specific recommendations.
• 2.1.6 In the patient receiving PD who is manifesting signs of modality failure, the decision to create a backup fistula should be individualized by periodically reassessing need. In individuals at high risk for failure (see the PD Adequacy Guidelines), evaluation and construction should follow the procedures in CPG 1 for patients with CKD stage 4.

2.2 Fistulae:

• 2.2.1 Enhanced maturation of fistulae can be accomplished by selective obliteration of major venous side branches in the absence of a downstream stenosis. (B)

2.3 Dialysis AVGs:
• 2.3.1 The choice of synthetic or biological material should be based on the surgeon's experience and preference. The choice of synthetic or biological conduits should consider local experience, technical details, and cost. (B)
• 2.3.2 There is no convincing evidence to support tapered versus uniform tubes, externally supported versus unsupported grafts, thick- versus thin-walled configurations, or elastic versus nonelastic material. (A)
• 2.3.3 While the majority of past experience with prosthetic grafts has been with the use of PTFE, other prosthetics (eg, polyurethane [PU]) and biological conduits (bovine) have been used recently with similar outcomes. (B)
• 2.3.4 Patients with swelling that does not respond to arm elevation or that persists beyond 2 weeks after dialysis AV access placement should receive an imaging study or other noncontrast study to evaluate central venous outflow (see CPG 1). (B)

2.4 Catheters and port catheter systems:

• 2.4.1 The preferred insertion site for tunneled cuffed venous dialysis catheters or port catheter systems is the right internal jugular vein. Other options include the right external jugular vein, left internal and external jugular veins, subclavian veins, femoral veins, and translumbar and transhepatic access to the IVC. Subclavian access should be used only when no other upper-extremity or chest-wall options are available. (A)
• 2.4.2 Ultrasound should be used in the placement of catheters. (B)
• 2.4.3 The position of the tip of any central catheter should be verified radiologically. (B)

RATIONALE

Order of Placement (CPG 2.1)

There are no randomized controlled trials (RCTs) comparing the recommended anatomic order of distal-to-proximal access construction. However, good surgical practice makes it obvious that when planning permanent access placement, one should always consider the most distal site possible to permit the maximum number of future possibilities for access. In general, a peripheral-to-central sequence of fistulae construction should be envisioned in the ideal case, beginning with the “snuff box” fistula at the base of the thumb, followed by the standard Brescia-Cimino wrist fistula, followed by a forearm cephalic fistula at dorsal branch and finally a midforearm cephalic fistula. If a forearm fistula is not feasible, an antecubital fistula, cephalic fistula at elbow, and, finally, a transposed basilic fistula should be considered. In cases in which a fistula is not constructed initially, a graft can be used as a “planned bridge” to a fistula. Failing forearm grafts can be converted to upper-arm fistulae, and lower-level fistulae can be
converted to higher-level fistulae. If a graft is constructed, preference is given to the following sequence: forearm loop; upper-arm, straight or curved; upper-arm loop. All upper-extremity options should be considered before using the thigh. At times, “exotic” grafts can be constructed on the anterior chest wall or to the internal jugular vein. Even in these situations, a systematic radiological evaluation of the venous systems should be conducted before placement.

Maintaining long-term functioning access can be difficult and frustrating for physicians and patients; starting distally and moving proximally provides for the possibility of preserving as many potential sites as possible for future access creation. It is a tragedy for patients and caretakers alike to exhaust anatomic sites prematurely by initially bypassing more distal sites. The decision to use a more proximal site initially should be documented by preoperative imaging studies or the likelihood for the development of arterial “steal.” However, if upper-extremity options have been exhausted, the anatomic locations left for permanent access are the thigh (where grafts and, less commonly, fistulae can be constructed) and upper chest, where a variety of graft accesses can be constructed. The possibilities in the chest usually are defined by preoperative evaluation of the central venous system and, at times, angiography or MRA is required. Because vascular access infection is intrinsically more likely in the thigh, access construction in this site usually is deferred to one of last resort. Graft patency in the thigh is minimally better than in the upper arm, and the greater risk for infection mandates against its initial use. In extreme cases, the forgotten Thomas shunt can be constructed.

The preference of fistulae over all other forms of access arises from their functional advantages because of a lower rate of complications.

- Fistulae have the lowest rate of thrombosis and require the fewest interventions, providing longer survival of the access. The number of access events is 3- to 7-fold greater in prosthetic bridge grafts than in native fistulae.
- As a result, costs of implantation and access maintenance are the lowest.
- Fistulae have lower rates of infection than grafts, which, in turn, are less prone to infection than percutaneous catheters and subcutaneous port catheter systems. Vascular access infections in HD patients are common, can be severe, and contribute to infection as the second leading cause of death in patients with CKD stage 5.
- Fistulae are associated with increased survival and lower hospitalization.
  - Patients receiving catheters (RR = 2.3) and grafts (RR = 1.47) have a greater mortality risk than patients dialyzed with fistulae.
  - Epidemiological evidence also indicates that greater use of fistulae reduces mortality and morbidity.

Wrist (radiocephalic) and elbow (brachiocephalic) primary fistulae are the preferred types of access because of the following characteristics:
• Superior patency to other accesses after they are established and matured.\textsuperscript{3,23,24,57,58,63-69}
• Lower complication rates compared with other access options,\textsuperscript{3,23,24,63-69} including lower incidence of conduit stenosis, infection, and vascular steal phenomenon.

In most cases, flow increases early (first week), with little additional increase as the fistula matures (see CPG 5).\textsuperscript{70-72} Failure of fistula flow to increase is a sign of access dysfunction (see CPG 4).

The Work Group concluded that the 3 advantages of wrist and elbow primary fistulae, as listed, outweigh the following 4 potential disadvantages:

• The vein may fail to enlarge and/or increase blood flow to satisfactory levels (ie, fail to mature).\textsuperscript{23,24,73}
• Comparatively long maturation times (1 to 4 months) must elapse after 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 CPG 1).
• In some individuals, the vein may be more difficult to cannulate than an AVG. However, this can be addressed by mobilizing the vein superficially.\textsuperscript{74}
• The enlarged vein may be visible in the forearm and be perceived as cosmetically unattractive by some individuals.

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

• It is relatively simple to create.\textsuperscript{61,75}
• It preserves more proximal vessels for future access placement.\textsuperscript{23,24,73}
• It has few complications. Specifically, the incidence of vascular steal is low, and in mature fistulae, thrombosis and infection rates are low.\textsuperscript{3,4,24,57,58,65,66}

The only major disadvantage of the wrist (radiocephalic) fistula is a lower blood flow rate (BFR) compared with other fistula types. If adequate flow to support the HD prescription is not achieved with a radiocephalic fistula within 4 months after appropriate evaluation for correctable or modifiable factors (see CPG 4), another type of access should be established (see CPG 1). The major drawback of a radiocephalic fistula is the relatively high primary failure rate (15%) and only moderate secondary patency rate at 1 year (62%).\textsuperscript{76}

The elbow (brachiocephalic) primary fistula is the second choice for initial placement of an access. Its advantages include the following:\textsuperscript{62,63,68,77-79}

• It has a higher blood flow compared with the wrist fistula.
• The cephalic vein in the upper arm usually is comparatively easier to cannulate and is easily covered, providing a potential cosmetic benefit.
The disadvantages of the elbow (brachiocephalic) primary fistula include the following:26,66,77-80

- It is slightly more difficult to create surgically than a radiocephalic fistula.
- It may result in more arm swelling than a radiocephalic fistula.
- It is associated with an increased incidence of steal compared with a radiocephalic fistula.
- It is associated with a greater incidence of cephalic arch stenosis than a forearm radiocephalic fistula.

If a wrist radiocephalic or elbow brachiocephalic fistula cannot be created, the patient should be considered for a transposed basilic vein fistula. In some cases, a forearm graft can be a viable alternative to mature the venous system for an elbow fistula as a secondary access. Transposed brachiobasilic fistulae have several disadvantages compared with other fistulae:62,66,79,81-83

- The transposition procedure may create significant arm swelling and patient pain.
- They have a greater incidence of steal and arm swelling than other fistula types.
- They are more technically challenging, especially in obese individuals.

The NVAII, now recognized as the FFBI, is a CMS-mandated 3-year CKD Stage 5 Network improvement project emphasizing a fistula-first approach.84-88 The Work Group agrees with the “mission statement” to “increase the likelihood that every eligible patient will receive the most optimal form of vascular access for him/her, in the majority of cases an arterial venous fistula.” For FFBI to optimally succeed, all its recommendations must be followed (NVAII, last accessed 2/20/2006). However, the Work Group recognizes that in some cases, the “fistula first at all costs” approach may not be the most cost-effective or optimal for each individual. A functional fistula is the goal, not the insertion of a fistula with a poor chance at maturing. A graft can be used as a “planned bridge” to a fistula, and failing forearm grafts can be converted to upper-arm fistulae. Similarly, fistulae at a lower level can be converted to more proximal fistulae.

AVGs have the following advantages:

- A large surface area and vessel available for cannulation initially.64,89-91
- They are technically easy to cannulate.64
- The lag-time from insertion to maturation is short. For PTFE-derived grafts, it is recommended that not less than 14 days should elapse before cannulation to allow healing and incorporation of the graft into local tissues,25,64,92 although ideally, 3 to 6 weeks are recommended.
- Multiple insertion sites are available.26,64,67,90-94
- A variety of shapes and configurations is available to facilitate placement.64,67,89-92,94
- It is easy for the surgeon to handle, implant, and construct the vascular anastomosis.25,26,64,91,92,94-104
• The graft is comparatively easy to repair either surgically or endovascularly.

The sum of the available data, until recently, supported PTFE grafts over other biological and other synthetic materials, based on lower risk for disintegration with infection, longer patency, better availability, and improved surgical handling. Biological grafts (bovine heterografts) have greater reported rates of complications compared with synthetic grafts.

For nearly 2 decades, PTFE has been the material of choice for bridge grafts. However, during the past decade, modifications and the use of other materials, such as PU, cryopreserved femoral vein, bovine mesenteric vein, and hybrids with self-sealing composite material, have been developed and used. None of these has shown any “survival” patency over plain PTFE, except for the composite/PU graft. The latter has an advantage because of its self-sealing property to be cannulated within hours, if needed, for dialysis. As a result, it can be placed without having to use a catheter for initiation of dialysis therapy, in some cases. Direct comparisons between PTFE and human umbilical cord vein grafts and other synthetic polymers have not been made.

The lure to construct AVGs using larger more proximal vessels should be resisted. Although these have higher flow and better initial function and/or patency, they limit potential sites for future placement. A synthetic dialysis AVG is expected to last 3 to 5 years.4,23,25,73 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 access creation should this become necessary in the future.4,23,25 The 2 preferred graft site types are the antecubital loop graft and upper-arm curved graft. Femoral placement of access has been associated with proximal venous stenosis, which may be problematic later in patients receiving kidney transplantation.

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.

Fistulae (CPG 2.2)
A 70% AV “working” fistula access rate can be achieved, even in patients who have diabetes and women. Results from the Dialysis Outcomes and Practice Patterns Study (DOPPS) indicate that the fistula can be cannulated as early as 1 month after construction.120 Thus, an access that shows evidence of maturation failure on physical examination or by using duplex ultrasound should undergo investigation. A study found that combining venous diameter (>0.4 cm) and flow volume (>500 mL/min) increased the predictive power of adequate fistula maturation to 95% (19 of 20) versus neither criterion met (33%; 5 of 15).72 Women were less likely to have an adequate outcome vein diameter of 0.4 cm or greater: 40% (12 of 30) compared with 69% in men (27 of 39).
However, of note, the accuracy of experienced dialysis nurses in predicting eventual fistula maturity was excellent at 80% (24 of 30).

Many accesses with multiple outflow veins can be salvaged by ligation of side branches. As more older patients have fistula constructions, the possibility of the access failing to mature is likely to increase. Failure to mature should be evaluated by 6 weeks after construction by physical examination and, if needed, ultrasound. Prompt correction should be undertaken.

*Exercises to Mature the Fistula (B-)*
Isometric exercise has been shown to increase the diameter of forearm veins, and exercise should be prescribed if there is sufficient lead time before surgery.

**Dialysis AVGs (CPG 2.3)**
Graft patency is independent of manufacturer, unaffected by an external wrap around the graft, and is not affected by wall thickness. The provision of a cuff or hood at the venous outflow to enlarge the outflow and reduce shear stress has produced only a marginal increase in graft patency. To control inflow or shear stresses, a variety of tapers have been examined at both arterial and venous anastomoses. There seems to be little effect from using a 6- to 8-mm graft compared with the standard straight 6 mm. A straight 8 mm also can be used and gives the highest flows. Arterial tapers are used to restrict inflow and reduce the risk for steal syndrome. Their effectiveness is questionable, and they may negatively affect patency and survival.

As previously discussed in CPG 2.1, a variety of modifications to the graft or other materials is available to the surgeon. Several studies are available to guide the interested reader. Predictors for successful placement of AVGs have been analyzed. The neointimal hyperplasia that produces stenosis has been considered to be, in part, a reaction to injury. No improvement in patency was noted in an RCT that compared staples with standard sutures at the vascular anastomoses. Use of nitinol surgical clips produces less intimal damage than conventional sutures, but RCTs showing a resulting change in outcome are lacking.

It should be remembered that a short segment of graft material can be used to develop a predominant fistula at the elbow.

**Catheters and Port Catheter Systems (CPG 2.4)**

*Basic Principles*

1. Long-term catheter systems—tunneled cuffed catheters (TCCs) and tunneled port catheter systems—should have their tips within the right atrium confirmed by fluoroscopy for optimal flow.
2. Short-term catheter tips should be in the superior vena cava (SVC) and confirmed by using chest radiograph or fluoroscopically at the time of placement before initiating dialysis therapy.

3. Uncuffed HD catheters should only be used in hospitalized patients and for less than 1 week. Uncuffed femoral catheters should only be used in bed-bound patients.

4. There should be a plan to: i) discontinue, or ii) convert any short-term catheter to a long-term catheter within 1 week.

5. Long-term catheters and port catheter systems, if possible, should not be placed on the same side as a maturing AV access.

6. Femoral catheters should be a suitable length to deliver high-volume flow and be positioned to minimize recirculation. One that does not reach the IVC frequently cannot deliver 300 mL/min. Longer catheters (24 to 31 cm) are more likely to reach the desired position, although there is more resistance from the catheter length.

7. There currently is no proven advantage of 1 long-term catheter design over another, although this area is undergoing a great deal of study. Catheters capable of a rapid BFR (>350 mL/min at prepump pressures not more negative than 250 mm Hg) are preferred. Catheter choice should be based on local experience, goals for use, and cost.

8. **Pediatric exception:** Some pediatric data exist suggesting that the twin-catheter system may provide better performance than the standard dual-lumen catheter configuration. Please refer to the Pediatric Guidelines.

9. Dialysis port catheter systems may be used in lieu of long-term catheters for a bridge access or as a permanent access for patients.

Catheter devices can be defined according to design, intent, and duration of use. For the entirety of the discussion, catheters will be referred to as acute short-term noncuffed catheters (NCCs) or long-term TCCs intended as access for dialysis over weeks to months. The term right arterial catheter should be avoided. They are either NCCs and placed predominantly for acute use (3 to 5 dialyses within 1 week) or TCCs and placed when the need for dialysis therapy is believed to be longer than 1 week. Long-term catheters usually are tunnelled. The catheters themselves usually are dual lumen and can be coaxial (now unusual) or “double D” (most common) and are either stepped (ie, the arterial and venous tips are staggered by 1 to 2 cm) or split so that the tips are not next to each other. Newer designs incorporate a spiral separator allowing either lumen to be used as the arterial port catheter system.

Port catheter systems are a distinct kind of catheter-based device system in which the catheter tubing is connected to a subcutaneously placed device. In the only port device currently in use for HD, access to the catheter lumen occurs percutaneously by using a buttonhole technique. These port catheter systems have a pinch valve mechanism that requires special cannulation needles to open the valves accessing the circulation.
Tunneled Cuffed Venous Catheters

Tunneled cuffed venous catheters have been shown to have the following advantages, relative to other access types:

1. They are universally applicable.
2. They can be inserted into multiple sites relatively easily.
3. No maturation time is needed, ie, they can be used immediately.
4. Skin puncture not required for repeated vascular access for HD.
5. They do not have short-term hemodynamic consequences, eg, changes in cardiac output or myocardial load.
6. They have lower initial costs and replacement costs.
7. They possess the ability to provide access during a period of months, permitting fistula maturation in patients who require immediate HD.
8. They facilitate correcting thrombotic complications.

Tunneled cuffed venous catheters possess the following disadvantages relative to other access types:

1. High morbidity caused by:
   - Thrombosis
   - Infection
2. Risk for permanent central venous stenosis or occlusion.
3. Discomfort and cosmetic disadvantage of an external appliance.
4. Shorter expected use-life than other access types.
5. Overall lower BFRs, requiring longer dialysis times.

Tunneled cuffed venous catheters should be placed in an area where ultrasound guidance and fluoroscopy are available. The preferred site is the right internal jugular vein because this site offers a more direct route to the right atrium than the left-sided great veins. Catheter insertion and maintenance in the right internal jugular vein are associated with a lower risk for complications compared with other potential catheter insertion sites. Catheter placement in the left internal jugular vein potentially puts the left arm's vasculature in jeopardy for a permanent access on the ipsilateral side. Catheter placement in the left internal jugular vein may be associated with poorer BFRs and greater rates of stenosis and thrombosis. Femoral and translumbar vein placement are associated with the greatest infection rates compared with other sites. Catheters should not be placed in the subclavian vessels on either side because of the risk for stenosis, which can permanently exclude the possibility of upper-extremity permanent fistula or graft. Catheters should not be placed on the same side as a slowly maturing permanent access. Catheter-induced central vein stenosis is related to the site of insertion, number and duration of catheter uses, and occurrence of infection.

Ultrasound insertion has been shown to limit insertion complications. Evidence is sufficient to recommend that ultrasound guidance be used for all insertions because it minimizes inadvertent arterial cannulation. Fluoroscopy allows ideal catheter tip placement to maximize blood flow. At the time of placement, the tip(s) of the
catheter should be in the midatrium, with the arterial lumen facing the mediastinum.

Use of catheters presents a conundrum because of the need for immediate vascular access versus the risk for complications from prolonged catheter use. Blood flow for dialysis obtained from catheters typically is less than that obtained from fistulae or grafts. Catheter length becomes crucial when TCCs are placed in the femoral area or through the translumbar or transhepatic routes. Correlations between arterial prepump or venous return pressures and dialyzer blood flows are not linear. It is possible to develop an optimal relationship between catheter length and diameter to achieve standardized (average, low, and high) blood flows regardless of the lengths of the catheters by incorporating the pressure-flow relationships, as well as Poiseuille's equation.

Use of catheters as first choice for long-term vascular access is discouraged because of infection, susceptibility to thrombosis, and inconsistent delivery of blood flow. In patients with documented inadequate vascular access anatomy, use of catheters is feasible with both double-lumen and twin-catheter systems. However, exceptions may occur in children.

In the United States, the demand for greater blood flows to reduce treatment times has resulted in catheters with larger lumens being placed. A variety of catheters can consistently deliver a flow greater than 350 mL/min to the dialyzer at prepump pressure of −200 to −250 mm Hg. The decision to use a step or a split design should be decided by local preferences. In general, all catheters will develop recirculation at some point, particularly if the arterial and venous blood tubing are reversed for any reason. This is minimized by using a split-tip catheter, but other designs are likely to produce the same effect.

The decision to use the femoral vein for long-term access (catheter or graft) as reported by some should be undertaken with great care. Any patient who has the option of undergoing a kidney transplantation should not have a femoral catheter placed to avoid stenosis of the iliac vein, to which the transplanted kidney's vein is anastomosed. The Work Group recommends the concept of shared governance in this type of decision, with both dialysis staff and transplant team planning long-term access for such patients. There are no data on the effect of catheter length from the femoral vein site. Although length increases resistance, it also reaches anatomic sites with greater IVC flow. If dialysis blood flow is less than 300 mL/min from a properly placed femoral catheter, guidewire exchange to a longer catheter should be considered.

Noncuffed Double-Lumen Catheters
These catheters are suitable for percutaneous bedside insertion and provide acceptable BFRs (300 mL/min) for temporary HD.

These catheters are suitable for immediate use, but have a finite use-life and therefore should not be inserted until they are needed. The rate of infection for internal jugular catheters suggests they should be used for no more than 1 week. 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 IVC. The Work Group believes that TCCs are preferred for longer durations of HD therapy over NCCs because they are associated with lower infection rates and greater BFRs. Short-term catheters may be used for up to 1 week. Beyond 1 week, the infection rate increases exponentially. Actuarial analysis of 272 catheters (37 TCCs versus 235 NCCs) showed a difference in infection rates by 2 weeks. Infection rates per 1,000 days at risk for NCCs were more than 5 times as great as with internal jugular TCCs and almost 7 times greater with femoral NCCs.

Ultrasound-directed cannulation of NCCs minimizes insertion complications, as it does with TCCs, and should be used when available. Because most NCCs are placed at the bedside, the need for a postinsertion chest radiograph after internal jugular or subclavian insertion is mandatory to confirm the position of the catheter tip in the SVC and exclude such complications as pneumothorax and hemothorax. Although there are no studies reporting on the safety of patients with NCCs going home while awaiting placement at a dialysis center, the Work Group believes that the risk for infection, inadvertent removal, hemorrhage, air embolism, and patient comfort mandates that patient safety come first. Therefore, a patient with an NCC should not be discharged. A short-term catheter can be converted to a TCC if there is no evidence of active infection.

Port Catheter Systems
In an effort to surmount many of the infection problems associated with long-term catheters, totally implantable access systems have been designed. Clinical data support the use of subcutaneous HD access systems as a bridge device in patient populations at greater risk for fistula maturation failure or needing longer periods to mature fistulae (>1 operation or multiple attempts need to be made). Studies also documented the utility of subcutaneous HD access systems in catheter-dependent patients who have exhausted other access options and in children. The most significant limitation of these devices has been infection, particularly of the implantation pocket. Although these can be treated successfully, prevention is key. Recommended procedures for accessing and maintaining these devices are mandatory to achieve optimal device performance.

Complications of catheter access are detailed more fully in CPG 7, and accessing the patient's circulation is discussed in CPG 3.

LIMITATIONS
The recommendations made in this section are based on the best currently available information and basic principles of surgery. No RCTs will ever be performed comparing the 3 access types available, nor should they be in view of the known risks of catheters. However, developments in the future of synthetic materials or the prevention of neointimal hyperplasia may permit such trials.

SUMMARY
Management of the patient who requires HD access for KRT demands continuous attention from the VAT. With the increase in incidence of HD-dependent patients with CKD within our population, the multidisciplinary KDOQI CPGs and CPRs presented provide a pathway and strategy for HD access insertion and/or creation. The most appropriate initial access depends on immediate need for HD, history and physical examination findings, and suitability of available veins in the extremity. Percutaneous catheter-based access affords the luxury of immediate access and absence of requirement for cannulation; however, these devices are plagued by their propensity for infection, thrombosis, inadequate blood flow, and—most importantly—damage to large central veins, leading to stenosis and jeopardizing long-term permanent access. The fistula access, while at times less successful in the immediate short term, is always the preferred long-term access type because of its greater longevity, fewer interventions for maintenance, and lower infection rates. The surgeon should focus on sites distally on the extremity, reserving proximal sites for potential future access insertions should the initial access site fail. In the absence of a suitable vein for a fistula, prosthetic access can be considered. When all sites in the upper extremities have been exhausted, the lower extremity or chest should be considered for access creation. Long-term catheters and port catheter systems should be reserved for last except in those with severe comorbidities, such as congestive heart failure (CHF) and severe peripheral vascular disease (PVD), the very elderly, those with inadequate vascular anatomy, or those with limited life expectancy.

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