

II. VASCULAR ACCESS DEVICES (VADS)

A. Overview of VADs

1. History: Further development of VADs continues to reduce the risk of accidental needlesticks and increase safety for healthcare personnel. Development and refinement of VADs continues to improve upon infection rates and thrombosis occurrence and enhance patient comfort.
 - a) Peripheral: Introduced in 1945 as a plastic catheter to deliver IV solutions (Prue-Owens, 2006; Prunet et al., 2008). Approximately 60% of hospital inpatients have a peripheral IV (Morris & Tay, 2008).
 - b) Midline: Midline catheters were first used in the 1950s for surgical patients who required one week of infusion therapy (Anderson, 2004). In the 1980s, the split-away plastic introducer was developed to facilitate midline catheter placement.
 - c) Nontunneled central venous catheters, apheresis/hemodialysis catheters (Putigna & Solenberger, 2009)
 - (1) Polyethylene catheters were first used for medical catheters in 1945.
 - (2) Central venous access was accomplished through the femoral and external jugular vein in 1949.
 - (3) In 1952, the subclavian vein was used for central access.
 - (4) In 1968, hyperalimentation was given through central access.
 - d) Peripherally inserted central catheters (PICCs): Introduced in the 1980s and mainly used for venous access in homecare patients (Bowe-Geddes & Nichols, 2005).
 - e) Tunneled (Putigna & Solenberger, 2009)
 - (1) Broviac tunneled catheters were first introduced in 1975 for long-term hyperalimentation. Catheter was tunneled within the subcutaneous (SC) tissue to increase the longevity of the catheter and to decrease infection.
 - (2) A larger bore catheter, the Hickman catheter, was introduced in 1976 to expand the applications of a tunneled catheter as well as the patient population.
 - f) Ports: Developed in the early 1980s to minimize infection risks and reduce care required at the insertion site
2. Definitions
 - a) Short term: Catheters inserted for a short period of time, such as up to six weeks (peripheral, midline, nontunneled catheters)
 - b) Long term: Catheters inserted for a time greater than six months (PICCs, tunneled, implantable ports)
3. VAD catheter materials and available features (Gallieni, Pittiruti, & Biffi, 2008; Galloway & Bodenham, 2004; Lopez et al., 2009)
 - a) Teflon® (DuPont): Material used for peripheral IV devices; not commonly used
 - (1) Stiff material that causes damage to the vein intima (inner lining) during insertion
 - (2) Best used in short-term devices for less than 96 hours
 - b) Polyurethane: Firm, not stiff, material that softens and becomes more pliable in the vein in response to the body core temperature
 - (1) Exceptional tensile (physical) strength and flexible endurance that permits the catheter to be constructed with a thinner wall and greater internal diameter for high flow rates
 - (2) Smaller external diameter catheters that can be used with less trauma for easier percutaneous insertion and decreased risk of phlebitis and other infectious complications
 - (3) Increased biocompatibility within the body and less adherence of fibrin to the catheter material (thromboresistant)
 - (4) Used for short-term peripheral devices and long-term devices
 - c) Silicone: Flexible material that causes less damage to the intima of the vein on insertion and allows the catheter to float within the vein, which may decrease the risk of thrombosis (Galloway & Bodenham, 2004)
 - (1) Requires special insertion technique because of flexibility of material (i.e., peel-away sheaths, Seldinger/modified Seldinger, micropuncture technique)
 - (2) Offers increased biocompatibility within the body and less adherence of fibrin to the catheter material (thromboresistant)
 - (3) Used for long-term access devices
 - d) Antimicrobial coating: Catheter coated with a substance that gives it an anti-infective quality to protect against potential bacterial seeding onto the catheter surfaces (Borschel et al., 2006; Centers for Disease Control and Prevention [CDC], in press; Ramritu et al., 2008)

- (1) Catheter surfaces are coated, bonded, or impregnated with an anti-infective substance. Agents that have been studied prior to insertion include the following.
- (a) Antimicrobials: Cephalosporins, penicillin, vancomycin, rifampin, minocycline, miconazole (Fraenkel et al., 2006; Hockenhull et al., 2008, 2009; Niel-Weise, Stijnen, & van den Broek, 2007)
 - (b) Antiseptics: Chlorhexidine, silver sulfadiazine, benzalkonium chloride, silver-platinum-carbon (Kalfon et al., 2007; Khare et al., 2007)
- (2) All of these substances have been shown to decrease the incidence of catheter-related bloodstream infections; however, their effectiveness is relatively short term (one to four weeks), and the evidence is contradictory (Borschel et al., 2006; Brun-Buisson et al., 2004; Dunser et al., 2005; Hanna et al., 2004; Leon et al., 2004; Rupp et al., 2005; Yucel et al., 2004). Therefore, more research is indicated to determine if their use could result in decreased costs as related to infection occurrence.
- (3) Patients are at risk for allergic reaction to the anti-infective substance.
- e) Heparin coating: Catheter coated with heparin prior to insertion to promote biocompatibility within the vein, thus reducing fibrin formation (Anton et al., 2009; Shah & Shah, 2007)
- (1) It is thought that heparin will decrease fibrin buildup and thus decrease the occurrence of infection.
 - (2) Drawbacks associated with heparin-bonded catheters include heparin-induced thrombocytopenia (HIT), increased risk of bleeding, allergic reactions, and increased costs (Anton et al., 2009; Shah & Shah, 2007).
- (3) Although more research on heparin coating is needed, limited studies show that heparinization reduces the frequency of catheter-related bloodstream infections at a relatively low cost over a short time period (Shah & Shah, 2007).
- f) PASV is a three-way pressure-activated safety valve located in the catheter hub designed to permit fluid infusion and reduce the risk of blood reflux into the catheter lumen during increases in central venous pressure that occur with exercise or involuntary responses, such as coughing.
- (1) The three-way safety valve resists fluid or blood backflow, reducing need for clamps and potentially reducing the risk of occlusion and infection.
 - (2) This unique three-way valve is pressure activated and direction specific and generally eliminates the need for heparin flush (Navilyst Medical, Inc., n.d.).
- g) Catheter distal tips are available with a valve or open ended.
- h) Radiopaque availability: Common feature of VADs
- (1) Assists in confirming placement in the vein under fluoroscopy or radiographically. Catheters are available with radiopaque lateral stripes or dots within the distal tip.
 - (2) Certain radiologic technologies may need to be implemented to assist with interpretation, such as the use of contrast medium.
- i) Catheter sizes are measured in French (Fr) or gauge. French size equals the outside diameter of the catheter in millimeters multiplied by three. Gauge, which ranges from 13 to 28, may indicate inner or outer diameter, with a smaller number indicating a larger size. To minimize the risk of vein stenosis and thrombosis, the smallest diameter required for therapy should be used (Knutsd, Hager, & Hauser, 2003).
4. Costs include insertion kits, the device, the insertion setting (e.g., operating room, bedside, outpatient clinic; interventional radiology), placement verification (chest x-ray or fluoroscopy), and maintenance supplies (Gallieni et al., 2008).

- a) Medical supply distributors, home health-care companies, and home infusion services are resources for nursing care, equipment, and supplies in the home setting.
 - b) Health insurance generally covers insertion expenses. Patients should check with their insurance representative or case managers about reimbursement issues.
 - c) Maintenance supplies, such as dressing materials, flushing/locking solutions, and syringes, generally are covered. Patients should check with their insurance company about reimbursement issues. Maintenance costs are based on the frequency of care (e.g., daily dressing changes or weekly dressing changes, daily flushing or every-other-day or weekly flushing).
5. Insertion technique: See specific catheter (Institute for Healthcare Improvement [IHI], n.d.; Venkatram, Rachmale, & Kanna, 2009).
- a) Care bundles are a group of evidence-based interventions for insertion of VADs.
 - b) Implementation of the care bundles results in a decrease in infections.
 - c) Care bundle grouping for insertion includes
 - (1) Strict hand hygiene
 - (2) Maximal barrier precautions upon insertion
 - (3) Chlorhexidine skin cleansing
 - (4) Optimal insertion-site selection with avoidance of the femoral vein
 - (5) Daily assessment of VAD
 - (6) Remove VAD when no longer needed.
6. Maintenance and care of VADs
- a) Common maintenance procedures (see Table 1) (Camp-Sorrell, 2007; CDC, in press; Gillies et al., 2003; Infusion Nurses Society [INS], 2006; Lyons, Given, & Marshall, 2008)
 - (1) Organize care to minimize entries into the VAD system.
 - (2) Maintain strict aseptic technique for all procedures (Olson et al., 2004). Hand hygiene is a vital intervention to reduce healthcare-associated infections (Koff et al., 2009; Morris & Tay, 2008)
 - (3) Standardized procedures should be performed by skilled personnel instructed to assess for signs of VAD-related complications, such as pain, redness, swelling, induration, tenderness, fever, chills, and inability to infuse fluid or withdraw blood.
 - (4) Secure all tubing connections with Luer locks.
 - (5) Avoid use of tape on tubing connections because it has been implicated in the transmission of bacterial contaminants (INS, 2006).
 - (6) Change dressing, IV tubing, or protective cap promptly if it becomes wet, soiled, contaminated, or damaged.
 - (7) Further research is needed to determine the most effective technique for dressing changes and the use of sterile versus nonsterile gloves during dressing change.
 - (a) By definition, *sterile* refers to a condition of being free from living microorganisms or germs.
 - (b) *Aseptic* refers to a condition free from septic matter or free from organisms.
 - (c) *Clean technique* refers to keeping the area free of debris or organisms.
 - (d) No current recommendations exist for which method to use.
 - b) Site care and dressing management are necessary for infection control and assessment of the VAD exit site, insertion site, and surrounding area. Supplies for site cleansing and dressing changes should be single-use only (Pratt et al., 2007).
 - (1) Technique for cutaneous antisepsis: In the past, the generally accepted method for applying skin-cleansing agents was to begin at the catheter exit site and cleanse outward in a circular motion, using care not to return to the clean area with the used sponge or swabstick. However, the manufacturer of Chloraprep® (CareFusion, Inc.) recommends using a back-and-forth motion for 30 seconds for skin cleansing (see www.chloraprep.com/directions-of-use).

- (a) When cleansing the insertion or exit site, use gentle friction for 30 seconds to ensure the disinfectant is absorbed by bacteria in the deeper layers of the skin (Camp-Sorrell, 2007; Morris & Tay, 2008)
- (b) Note that alcohol- and iodine-containing products may be contrain-

icated for use to clean or come in contact with certain catheter materials and some types of protective caps. Contact may weaken or compromise the material over time. Therefore, it is important to obtain specific manufacturer information for each VAD used in a specific practice setting.

Table 1. Common Maintenance Procedures for Vascular Access Devices

Vascular Access Device	Dressing	Flushing*	Cap Change**	Blood Discard
Peripheral and midline (i.e., angiocatheter, butterfly)	Transparent dressing change with IV change. Gauze dressing QOD or PRN if wet, soiled, or nonocclusive.	NS 1–3 ml every 8, 12, or 24 hours	Every week or with catheter change	0.5–1 ml
Central nontunneled (i.e., subclavian)	Dressing change 24 hours after insertion. Transparent dressing every five to seven days. Gauze dressing QOD or PRN if wet, soiled, or nonocclusive.	Heparin 10–100 IU/ml, 3 ml/day or 2 ml/day per each lumen. Valve catheter or closed tip catheter flushed with NS.	Every week or with catheter change	1–2 ml
PICC line	Dressing change 24 hours after insertion. Transparent dressing every five to seven days. Gauze dressing QOD or PRN if wet, soiled, or nonocclusive.	Heparin 10–100 IU/ml, 3 ml/day or 3 ml/day three times a week. Valve catheter or closed tip catheter flushed with NS.	Every week	1–2 ml
Tunneled	Dressing change 24 hours after insertion. Transparent dressing every five to seven days. Gauze dressing QOD or PRN if wet, soiled, or nonocclusive. Once tunnel has healed, no dressing unless immunocompromised.	Heparin 10–100 IU/ml, 3 ml/day; 3 ml every other day; 5 ml three times a week; or 5 ml weekly. Valve catheter or closed tip catheter flushed with NS.	Every week or month	3–5 ml
Implanted port	For continuous access, change noncoring needle and transparent dressing every week or if nonocclusive. Gauze dressing QOD or PRN if wet, soiled, or nonocclusive.	Heparin 100 IU/ml, 5 ml every month or every six to eight weeks and after each use. Valve catheter or closed tip catheter flushed with NS. Flush both lumens.	Every week for continuous access	5 ml
Valve or closed distal tip	See above sections.	NS 5–10 ml weekly or after each use	Every month	3–5 ml
Pheresis	Transparent dressing every five to seven days. Gauze dressing QOD or PRN if wet, soiled, or nonocclusive.	Heparin 1,000–5,000 IU/ml; 1–2 ml/day	Every week	5 ml
Hemodialysis	Transparent dressing every five to seven days. Gauze dressing QOD or PRN if wet, soiled, or nonocclusive.	Heparin 1,000–5,000 IU/ml after each treatment	Every week	5 ml

*VAD should be flushed with 10–20 ml of NS after blood withdrawal. All VADs should be flushed with NS before and after use.

** Change protective cap more frequently if signs of poor integrity of septum from multiple use, signs of blood, precipitate, cracks, leaks, or other defects.

NS—normal saline; PICC—peripherally inserted central catheter; PRN—whenever necessary; QOD—every other day

(2) Cleansing agents (see Table 2): Base protocol and product choices on current research review, patient-specific issues, and catheter materials.

(a) Alcohol: A bacteriocidal that derives its antimicrobial effect by denaturation of proteins. Alcohol should be applied after use of a tincture of iodine but not following use of povidone-iodine solution (INS, 2006).

(b) Iodophors: Complexes that consist of iodine and a carrier that stabilizes the product, thereby reducing skin irritation. Their antimicrobial effect is derived from cell wall penetration, oxidation, and substitution of microbial contents with free iodine. Povidone-iodine (10%) is the most commonly used iodophor. Antimicrobial activity of iodophor occurs during drying; therefore, it must be left on the skin for at least two to three minutes to dry completely. Iodophor has minimal residual effect because free iodine is depleted after drying. Efficacy also is diminished by the presence of organic matter, such as blood or exudates, on the skin.

(c) 2% chlorhexidine gluconate (CHG): Recommended for pre- and post-insertion catheter care (CDC, in press; Danks, 2006; Milstone, Passaretti, & Perl, 2008; Mimoz et al., 2007). CHG is an antimicrobial that derives its activity by causing disruption of microbial cell membranes and precipitation of cell contents. CHG has a

strong affinity for the skin, remaining chemically active for at least six hours. Antimicrobial action is rapid, and efficacy is not affected by organic material, such as blood or exudates on the skin.

i. CHG is superior to alcohol or povidone-iodine in preventing catheter infection (Mimoz et al., 2007; Valles et al., 2008). Meta-analysis of eight studies comparing CHG with povidone-iodine showed that CHG reduced the risk of catheter-related bloodstream infection by 49% (Chaiyakunapruk, Veenstra, Lipsky, & Saint, 2002; Mimoz et al., 2007).

ii. In 2000 the U.S. Food and Drug Administration (FDA) approved a 2% preparation, which is shown to substantially reduce infections, for use in preoperative skin preparation. It is now recommended for use during venous access device insertion in all patients older than two months of age unless contraindicated.

(d) Persist™ (Becton, Dickinson and Co.) skin preparation: This skin antiseptic allows release of iodine on the skin site for a longer time period to reduce skin irritation and promote antimicrobial action. Persist is a povidone-iodine formulation in an alcohol carrier that was developed as a catheter site antiseptic agent. According to the manufacturer, Persist is as effective as

Table 2. Comparison of Cleansing Agents

Agent	Mode of Action	Gram +	Gram –	TB	Fungi	Viral	Residual Activity	Duration of Anti-Infective Effect After Application
Alcohol 70%	Denaturation of protein	Excellent	Excellent	Good	Good	Good	None	Brief
Iodophor 10% (povidone-iodine)	Oxidation/substitution by free iodine	Excellent	Good	Good	Good	Good	Minimal	Two hours
Chlorhexidine gluconate 2%	Cell wall disruption	Excellent	Good	Poor	Fair	Good	Excellent	Four to six hours

TB—tuberculosis

other agents, such as alcohol and povidone-iodine.

- (e) Ointments: Routine application of antimicrobial ointment to catheter insertion and exit sites is **not** recommended because of the risk of fungal infections and antimicrobial resistance (CDC, in press; Pratt et al., 2007).

(3) Dressing materials

- (a) Gauze and tape: A mesh material traditionally used for dressings that provides no occlusive barrier, acts as a sponge, and is secured in place with various kinds of clean or sterile tape. Gauze dressings are to be changed every 48 hours or when wet, soiled, or the tape is no longer secure (Camp-Sorrell, 2007; CDC, in press; Krzywda & Edmiston, 2002).
- (b) Transparent dressing: A semipermeable film with a significant moisture vapor permeability rate that allows for visualization of the VAD exit site but acts as a barrier to extrinsic liquid and microorganisms. Transparent dressings are to be changed every five to seven days or more often, as indicated (CDC, in press; Gallieni et al., 2008). When gauze is placed under a transparent dressing, the dressing type is considered gauze and tape and should be changed every 48 hours.
- (c) Securement or stabilization devices: Steri-Strips™ (3M Health Care) or tape can be used to stabilize temporary catheters. Recommend to use securement devices, such as StatLock® (C.R. Bard Inc.), instead of sutures to reduce risk of infection (CDC, in press).
- (d) No current recommendations exist for the use of sterile versus nonsterile gloves during dressing changes (CDC, in press; Pratt et al., 2007). Use of a no-touch technique with sterile or nonsterile gloves is recommended to prevent bacterial contamination (Pratt et al., 2007).
- (e) No current recommendations exist for the use of a chlorhexidine sponge dressing (Biopatch® Antimicrobial Dressing, Johnson & Johnson). Biopatch is impregnat-

ed with chlorhexidine in a sustained-release formulation that is released over 5–10 days. A transparent dressing covers the patch. Studies suggest a decrease in catheter-related infections with CHG-impregnated dressings (Chambers et al., 2005; Ho & Litton, 2006; Ruschulte et al., 2009).

- (f) Antimicrobial barrier dressing: Contains silver ions, which provide a sustained release directly into and around the catheter insertion site to reduce infection (Silverlon®, Argentum Medical, LLC). No current recommendations exist for silver dressings.
- c) Flushing technique: Flushing is necessary to ensure patency by preventing accumulation of blood and drug precipitates on the catheter lumen. Flushing can prevent fibrin buildup; however, all VADs will accumulate fibrin coating to some extent. Flush vigorously using a pulsatile technique, and maintain pressure at the end of the flush to prevent reflux back into the catheter (Bishop et al., 2007; Camp-Sorrell, 2007; Hadaway, 2006; INS, 2008).
- (1) Positive pressure technique is extremely important in preventing the development of fibrin sheaths, leading to withdrawal or infusion occlusions and contributing to the development of venous thrombosis. The following procedures prevent the slight negative pressure on the end of the catheter that results in pulling a small amount of blood into the end of the catheter, where it becomes a fibrin sheath.
 - (a) Positive pressure is maintained while flushing a VAD by clamping the extension tubing while still flushing the line.
 - (b) VADs that do not have a clamp may be flushed with positive pressure by withdrawing the syringe from the injection cap while continuing to push fluid through the needle.
 - (2) Flushing solutions
 - (a) Heparin sodium (10–5,000 IU/ml) is a sterile solution that inhibits the conversion of prothrombin to thrombin and fibrinogen to fibrin, thus inhibiting coagulation. Higher concentrations, such as 1,000 IU/ml or greater, are used for hemodi-

alysis/apheresis catheters. Heparin is used to prevent fibrin buildup. Some authors have reported that use of heparin may decrease the incidence of catheter-related infections because of decreased risk of thrombus formation (Bishop et al., 2007; CDC, in press). Use of heparin may be contraindicated in patients at risk for heparin-induced thrombocytopenia.

(b) Bacteriostatic 0.9% sodium chloride solution is a sterile solution with approximately the same osmotic pressure and composition as extracellular fluids. Sodium chloride cleans the internal diameter of the catheter from blood or drug.

(3) Syringes/flush systems

(a) Drawing the solution from a vial into a syringe is the least expensive flushing method; however, it may not be appropriate in some patient care settings or for patients with poor eyesight or poor manual dexterity.

(b) Prefilled syringes reduce the risk of touch contamination from preparation and ensure administration of the correct flush and amount.

(c) Single-use flushing systems should be used.

(4) Flushing procedures and protocols

(a) Never use excessive force when flushing VADs. Avoid using a syringe less than 3 ml in size to decrease the pressure on the catheter. Syringe size directly affects the amount of pressure created by the force on the plunger; that is, the smaller the syringe, the greater the pressure in pounds per square inch (psi). The use of high pressure increases the risk of catheter/septum rupture or separation. For example, a 3 ml syringe generates pressure greater than 25 psi, whereas a 10 ml syringe generates less than 10 psi (Hadaway, 2006; INS, 2008). The manufacturer of the individual device determines the maximum pressure that can be exerted on a VAD. (Caution: This does not include physiologic variables that impact pressure, such as fibrin buildup.)

(b) Heparin-locked VADs should be flushed with saline before and after drug administration. If the VAD is being used frequently or locked with a high concentration of heparin, consider withdrawing heparin first to prevent giving therapeutic doses of heparin (Bishop et al., 2007).

(c) VADs with a closed distal tip (Groshong® [Bard Access Systems] valve catheters) or PASV are designed to be flushed vigorously with saline; however, some institutions flush with heparinized saline.

(d) Flush all VADs vigorously using pulsating technique (push-pull motion) with 10–20 ml of normal saline after infusing or withdrawing blood.

(e) Clamps are used as needed when accessing or deaccessing VADs to prevent air embolism or blood backflow.

i. Many VADs have clamps located directly on fortified areas of the catheter.

ii. Never use a hemostat or sharp-edged clamp that could damage or cut the catheter. Toothless plastic clamps should be kept available for emergency use. Scissors should never be used on or near the catheters except for removal of sutures (INS, 2006).

iii. If clamping is not possible, have the patient perform a Valsalva maneuver (forcefully exhale and hold breath) whenever catheter is open to air.

iv. Valved catheters or catheters with PASV do not require clamping if valve is functioning properly. Clamping will damage the catheter.

d) Protective cap: Since 1993, needleless connectors have been available to prevent needlestick injury. In 2000, the Occupational Safety and Health Administration mandated that needleless connectors be used in the clinical setting (Maragakis et al., 2006).

(1) Types of caps: Luer lock, needleless system cap, with or without positive

pressure feature, neutral caps, or antimicrobial coated with silver ions to help prevent microbial contamination

- (2) Prior to accessing injection cap, cleanse it vigorously with appropriate cleansing agent (Moran & Camp-Sorrell, 2002). If povidone-iodine is used, it must be allowed to dry for at least two minutes. Controversy exists as to the best type of agent to use.
- (3) Studies suggest that the use of a positive pressure device on the hub of a catheter may decrease the incidence of catheter-related thrombus by preventing retrograde flow of blood into the catheter lumen (Rummel, Donnelly, & Fortenbaugh, 2001; Yebenes et al., 2004). Other studies have revealed an increase in catheter-related bloodstream infections after using positive pressure caps (e.g., Maragakis et al., 2006). These authors recommend that infection-control programs carefully evaluate catheter-related infection rates to detect increases in occurrences.
- (4) Studies suggest a potential increase in catheter-related infections with some needleless system caps. If a new system is implemented, catheter-related infection rates should be closely monitored. Nurses who use these systems should understand their mechanism and follow manufacturers' recommendations for proper flushing procedure (Hadaway, 2006; Maragakis et al., 2006).
- (5) Change the cap every week or when any of the following occur.
 - (a) The cap is removed to initiate an infusion or draw blood.
 - (b) Blood cannot be completely flushed from the cap after blood withdrawal.

- (c) Signs of blood, precipitate, cracks, leaks, or other defects are noted.
- (d) The septum is no longer intact (e.g., after multiple uses with antibiotics).

e) Techniques for blood withdrawal

- (1) Discard method: This is the most commonly reported method used with the adult population. Blood is withdrawn and discarded prior to sample collection. Discard amounts reported vary from 3–10 ml, with 5–6 ml used most frequently (Adlard, 2008; Camp-Sorrell, 2007).
- (2) Reinfusion method: Instead of discarding the first collected sample, it is saved and reinfused into the patient at the end of sample collection. This method is used in the neonate and pediatric populations to prevent a decrease in blood volume. One study recommended that the discarded blood sample not be reinfused. In a small study of adults, clots were found in the discarded blood samples (Cosca et al., 1998).
- (3) Mixing method: Blood is withdrawn and immediately reinfused into the patient. This method is repeated four times without removing the syringe, and a sample is then taken. The purpose is to minimize blood loss. Studies found no significant errors in laboratory test results or increase in clots when compared to the discard method (Adlard, 2008; Barton, Chase, Latham, & Rayens, 2004).
- (4) Vacutainer method: This method involves inserting a vacutainer into the injection cap to reduce the risk of needlestick and blood contamination when transferring blood to tubes. Vacutainers used with some catheters, such as PICCs or valve catheters, may not yield a blood sample because the pressure may collapse the catheter.
- (5) Syringe method: A syringe is attached directly onto the catheter hub or needleless system, and blood is withdrawn into the syringe. This method may increase the risk of blood and specimen contamination because after blood collection, a needle is placed on the syringe to transfer blood to collection tubes.
- (6) If the VAD is connected to an infusion, discontinue all infusates for at

least one minute before withdrawing the blood sample. Clamp all lumens not being used for blood withdrawal on open-ended catheters.

- (7) If laboratory values appear to be grossly inaccurate, redraw a blood sample from a peripheral vein (Bishop et al., 2007).
 - (a) Blood coagulation studies should be drawn peripherally unless the catheter is maintained with normal saline, because heparin adheres to the internal catheter lumen and will alter the coagulation results. At some institutions, coagulation levels are drawn after other blood samples are obtained or after discarding 10 ml of blood; however, the literature does not support this practice.
 - (b) Some drugs (e.g., aminoglycosides, cyclosporine, gentamicin) can adhere to the catheter wall, which may obscure drug serum level testing (Bishop et al., 2007; Boodhan, Maloney, & Dupuis, 2006). Consider drawing these drug levels peripherally.
- f) Routine replacement of administration sets (Scales, 2008)
 - (1) Replace IV administration sets every 96 hours (at least 7 days) or with catheter change, except for fluids that enhance microbial growth (i.e., lipids, total parenteral nutrition [TPN], which should be changed daily); this practice is strongly recommended unless catheter-related infection is suspected (CDC, in press; Scales, 2008).
 - (2) IV administration sets changed at three days versus four to seven days in 428 low-risk patients (i.e., those not receiving TPN, blood products, or interleukin-2) had no difference in colonization rates (0.4% versus 0.5%) or catheter- or infusion-related bloodstream infections (Raad et al., 2001).
 - (3) The only study found to address neutropenic patients reported no difference between IV administration sets changed at 48 versus 24 hours in terms of incidence of colonization or infusion-related septicemia (DeMoissac & Jensen, 1998).
 - (4) Tubing used to administer lipids or TPN is replaced every 24 hours after initiation of therapy (CDC, in press).

- (5) Tubing for blood and blood components should be changed when the transfusion is complete or every 12 hours.
- g) Interventions to reduce the pain of IV insertion and port access should be considered, especially if they increase the chance of success. Interventions include topical anesthetics (see Table 3), injections, and non-pharmacologic techniques.
 - (1) An order from a healthcare provider is needed for any pharmacologic interventions. Topical anesthetic may obscure the vein, and vasoconstriction and vasospasm have been associated with topical application.
 - (2) Topical anesthetics include creams, patches, gels, and sprays (see Table 3). The majority of studies have been with pediatric populations and insertion of peripheral IVs with favorable response.

Table 3. Topical Anesthetics

Type	Application	Comments
Transdermal cream	Apply thick layer one to two hours prior to device access or IV insertion. Cover with transparent dressing. Remove cream completely, and cleanse site prior to insertion.	May cause localized blisters Small dose absorbed systemically
Transdermal patch	Apply 20–30 minutes prior to insertion.	May cause mild erythema and edema
Intradermal solution (i.e., 1% lidocaine without epinephrine)	With needle bevel up, gently insert needle intradermally above intended insertion site prior to insertion; instill a small amount of solution.	May cause discomfort with needle insertion Monitor for sensitivity to lidocaine.
Electrodes	Apply pads and connect to dose controller to release topical anesthesia in pads.	May cause skin irritation
Topical spray	Holding can several inches away from skin, spray a light mist onto skin and allow to dry prior to insertion.	May cause frostbite reaction

- (a) EMLA® (lidocaine 2.5% and prilocaine 2.5%) cream (AstraZeneca, LP) and ELA-Max® (Ferndale Labs) cream significantly decrease pain from venipuncture and IV insertion.
- Apply 2.5 g to 4 × 4 cm area for puncture, cover with semi-permeable transparent dressing for one to two hours, wipe off, and cleanse site as usual.
 - Cream may cause hypersensitivity, inadvertent systemic absorption after prolonged application, and erythema at site.
- (b) Numby Stuff® (Iomed Clinical Systems) is a topical, noninvasive delivery system with results found to be superior to other agents.
- Iontocaine® (Iomed's brand of lidocaine HCl 2% with epinephrine 1:100,000 topical solution) is used to hydrate the electrode pad.
 - Electrode sites are prepared with alcohol skin preparations, and electrodes are applied. The Numby 900 dose controller is attached to the pads. Typical preset dose is 40 mA.
 - After delivering the selected current level, the controller automatically turns off. Electrodes are removed, and skin is prepared for device insertion.
- (c) Ethyl chloride spray (Gebauer Co.) is a topical anesthetic skin refrigerant causing numbness and lasting only seconds. It may cause frostbite or skin ulceration and is very flammable. Frequent use to access a port on a weekly basis can be a cause of skin breakdown. Port erosion can result (Camp-Sorrell, 2004) (see Figure 1).
- Target area and spray three to seven seconds.
 - Effect lasts a few seconds to a minute.
- (d) Intradermal 2% lidocaine (1–2 ml) injection has been found to be effective, but it may cause erythema at site, inadvertent intravascular injection, pain with injection, or hypersensitivity.

Figure 1. Skin Erosion With an Implanted Port



Note. From "Implanted Ports: Skin Erosion," by D. Camp-Sorrell, 2004, *Clinical Journal of Oncology Nursing*, 8, p. 309. Copyright 2004 by the Oncology Nursing Society. Reprinted with permission.

- (e) Topical anesthetic patch (Synera® [70 mg lidocaine/70 mg tetracaine], ZARs, Inc.) has been found to be effective in reducing pain of IV insertion (Sethna et al., 2005).
- Transdermal patch (lidocaine 70 mg and tetracaine 70 mg) is applied to the insertion site. When removed from its storage pouch, the patch begins to heat from the heating element, warming the skin after application.
 - Patch is applied 20–30 minutes before insertion.
- (f) Using music as a distraction can reduce the pain associated with insertion. Other complementary therapy methods, such as acupuncture and hypnosis, also have been suggested.

B. Peripheral IV catheters (short term)

- Description and types of catheters (Scales, 2008)
 - A peripheral IV is used for a short time period (usually less than four days) and involves a short-length catheter (less than three inches) (CDC, in press).
 - Catheters are defined by their gauge, length, and design.
 - Gauges range from 14–28 with single-lumen designs.
 - Lengths range from 5/8–2 inches.

- (3) Some peripheral IVs are available with a longer stylet and with microbore extension tubing and hub attached. The longer stylet is removed, decreasing the risk of blood contamination or needlestick. Catheters are available with extension tubing attached with Y adapter.
 - c) Catheter material is made of silicone and polymers, including polyurethane, polyvinyl chloride, and flexane. Latex-free catheters also are available.
 - d) Specific types of peripheral infusion devices include the following.
 - (1) Steel-tipped, winged infusion (butterfly) needles
 - (2) Over-the-needle: Catheter sheath is externally located over the needle stylet.
 - (3) Through-the-needle: Catheter sheath is located inside the needle stylet.
 - (4) Needle protection: Shielded butterfly needles, stylet protective devices, and needleless IV access systems are available.
 - (5) Newer technology provides a closed IV catheter system with dual port extension tubing attached to permit solutions to be administered simultaneously.
 - (6) To reduce the risk of accidental needlestick injuries, active and passive safety devices have been developed on IV catheters (Lopez et al., 2009; Prunet et al., 2008). Passive safety catheters have an insertion typical of a standard catheter with a protective shield that automatically covers the needlepoint during its withdrawal from the catheter top without any intervention from the nurse inserting the catheter. Active safety requires pressing a button to trigger the withdrawal of the needle in a plastic sleeve using a spring.
 - (a) During a three-month period, Prunet et al. (2008) evaluated three peripheral catheters (nonsafety catheter, passive safety catheter, and an active safety catheter), examining a total of 759 catheter insertions.
 - (b) The numbers of failed insertions among the three types of catheters were similar. Insertion of the active safety catheter was found to be the most difficult and caused increased blood exposure to the staff. Needle withdrawal was more difficult with the passive safety catheter.
 - e) Peripheral IVs are available with radiopaque design.
 - f) Cost: Catheter is approximately \$1–\$2.50; insertion kits are available with supplies included at various costs. Example of insertion kit includes gloves, patient label, tape, chlorhexidine pad, 2 × 2 gauze, tourniquet, and transparent dressing for approximately \$1.50–\$5.
2. Advantages and disadvantages of using a peripheral IV (see Table 4)
 3. Patient selection criteria (Polovich, Whitford, & Olsen, 2009; Scales, 2008)
 - a) Patient's age, in general, does not restrict use of peripheral IV.
 - b) Indications for peripheral IV include the following.
 - (1) With adequate vascular integrity, peripheral IVs are recommended for short-duration, nonirritating infusions of less than seven days, which may include antimicrobials, analgesics, blood components, fluid and electrolyte replacement, and nonvesicant chemotherapy. Drugs that cannot be given orally because the molecules are too large to be absorbed or because they are destroyed by digestion are conveniently given by IV.
 - (2) Peripheral IVs are best used for simple, one-time-use IV therapies, such as administering an IV push of a vesicant or nonvesicant chemotherapy, because the IV is inserted only at the time of therapy and usually is discontinued immediately after the procedure is complete. Sclerosing of veins can occur over time.
 - (3) Patients with a short life expectancy are candidates for peripheral IVs.
 - (4) Peripheral IVs are not indicated for continuous vesicant therapy or solutions with a pH less than 5 or greater than 9, or osmolarity greater than 600 mOsm/L.
 - (5) Using peripheral IVs for blood specimens has mixed recommendations.
 - (a) The use of peripheral IVs for obtaining blood samples continues to be debated (Prue-Owens, 2006). In general, peripheral IVs flushed with 0.9% normal saline are simple and safe for collecting blood samples, based on the accuracy of sample.

Table 4. Advantages and Disadvantages of Vascular Access Devices

Type of Line	Advantages	Disadvantages
Peripheral IV	<ul style="list-style-type: none"> • May be inserted by an RN • Can be easy to insert and maintain • Provides quick, simple access to vascular system • May be used in all patient care settings • Involves minimal insertion costs compared to other venous access procedures 	<ul style="list-style-type: none"> • Has a short life span—approximately 72–96 hours (CDC, in press) • May involve discomfort with insertion • Can be difficult to insert and maintain in the very young, older adults, and those with fragile or sclerotic veins • Can be cumbersome and restrictive, especially when inserted near a joint or in a dominant limb • Requires daily care and maintenance • Peripheral vessels can quickly become irritated from infusions of blood components, concentrated dextrose solutions, chemotherapy, and parenteral medications, including antimicrobial agents and electrolyte infusions. • Less desirable access for infusions of vesicant agents (e.g., certain chemotherapy, calcium gluconate), electrolytes, and vasoconstrictors • Could be more costly if used long term, with repeated access, especially in home environment • Frequent site changes can exhaust all suitable peripheral veins.
Midline catheter	<ul style="list-style-type: none"> • Can be placed at the bedside by a specially trained nurse • Dwell time is one to eight weeks. • Chest x-ray is not required for placement because the tip is not in the central circulation. • Can be used for most IV solutions • Can be removed at the bedside • Relatively economical compared to more permanent lines • Fewer complications than surgically placed devices 	<ul style="list-style-type: none"> • Cannot be used for continuous infusion of vesicants • Not recommended for routine blood draws • Size and flexible nature of the catheter may decrease the ability to draw blood. • Contraindicated for solutions with final concentrations greater than 10% glucose or greater than 5% protein • Patients must have adequate peripheral veins. • Not available as a triple lumen • May cause arm discomfort or immobility • More prone to phlebitis, which may be insertion technique-dependent
Nontunneled central venous line	<ul style="list-style-type: none"> • May be used to infuse all IV therapies and draw blood • May be inserted at the bedside or in ambulatory surgery using sterile technique • May be inserted without general anesthesia or procedural sedation • May be used to monitor central venous pressure • May be placed in an emergency situation and used immediately • Does not require needle access for use after insertion • Designed for short-term use (up to six weeks) • Available in a variety of gauges and in single, double, and triple lumens • Can be used for multiple, incompatible solutions concurrently (double and triple lumen) • Available antimicrobial-impregnated catheters may decrease risk of infection. • Heparin-impregnated catheters available may decrease risk of venous thrombosis • Catheter valve available, eliminating the need for heparin flush • Power lines available 	<ul style="list-style-type: none"> • Must be placed by a physician. Some states may allow specially trained RNs to insert. • May be associated with discomfort at insertion • More prone to infection because of a lack of tunnel/cuff, the external portion, and insertion at bedside • Requires diligent aseptic care to prevent infection and maintain line function • Placement must be checked with x-ray prior to use. • Not used for long-term venous access • May not be suitable for testing of coagulation studies

(Continued on next page)

Table 4. Advantages and Disadvantages of Vascular Access Devices (Continued)

Type of Line	Advantages	Disadvantages
Peripherally inserted central catheter (PICC)	<ul style="list-style-type: none"> • May be used immediately after confirmed placement • May be inserted by an RN who has attended an instructional course and has demonstrated clinical competence in insertion technique • Insertion is relatively simple and may be performed at the bedside or in an outpatient setting. • Provides a safe, economical means of vascular access for therapies • Poses no risk of insertion-related pneumothorax or great vessel perforation • Demonstrates lower complication rate than other types of access devices if the device is inserted properly and is well maintained • Available in double or single lumen • Ideal for the very young and older adults because of the small size • Legitimate first choice for venous access in patients who are acutely or critically ill and who need intensive IV therapy and assurance of continuous venous access • Decreases stress exerted on the patient by the reducing number of venipunctures required to administer therapy • Excellent for use in homecare settings, as it decreases the need for unscheduled nursing visits related to site rotation or complications • May be used in all settings for the administration of a variety of IV therapies and to obtain blood samples • Less expensive than nontunneled short-term catheters, long-term catheters, or implanted ports • Power PICC available for contrast injections • Repair kits available 	<ul style="list-style-type: none"> • RN requires educational preparation and attainment of clinical competence. • RN must maintain level of skill and competence. Clinical opportunities for insertion and maintenance of PICC must be available on a consistent basis. • May not be the access device of choice to meet a patient's special needs. PICC should be considered one of several available vascular access devices (VADs) from which to select. • May limit arm movement if inserted in the antecubital area • May not be able to draw blood with small-gauge catheters • Some manufacturers recommend not using 2 French size for red blood cell transfusion. • More expensive than peripheral IVs
Tunneled catheter	<ul style="list-style-type: none"> • Can be used immediately after placement once radiographic confirmation is made • Preserves peripheral veins • Provides a means for rapid hemodilution of infused solutions • Provides a reliable source of IV access • Designed for long-term IV therapy for frequent venous access and functional for years • Available in single, double, and triple lumens • Provides preattached clamps, except for valved catheters • Tunneling potentially decreases risk of microorganisms entering the venous system because of anatomical distance between insertion and exit sites. • Repair kits for external segments available for tunneled catheters • A variety of sizes available to accommodate pediatric and adult patients • Power lines available 	<ul style="list-style-type: none"> • Requires routine exit-site care • Requires routine flushing of catheter lumens • Poses risk of complications, such as catheter-related infection and thrombosis • Cost of maintenance supplies includes dressings, flushing solutions, injection caps, syringes, and needles. • Body image changes can affect patient. • Insertion is a surgical procedure.

(Continued on next page)

Table 4. Advantages and Disadvantages of Vascular Access Devices (Continued)

Type of Line	Advantages	Disadvantages
Implanted venous port	<ul style="list-style-type: none"> • Can be left in place and be functional for many years • Ideal for intermittent access • Less potential for infection than external catheters • No dressing required when the port is not accessed; therefore, ideal for patients with tape sensitivities • Flushing only required every four to eight weeks when not in use • Less potential for catheter to migrate • Can be used to draw blood • Has less effect on body image • Catheter infection may be successfully treated with IV antibiotics, although fungal infections generally require removal of the line (Vescia et al., 2008). 	<ul style="list-style-type: none"> • Insertion is a surgical procedure. • Most expensive VAD to insert • Must be accessed with a needle • Catheter can disconnect from port and migrate, causing extravasation. • Presence of port may interfere with sleep • Over time, buildup of “sludge” (clotted blood, drug precipitates) may collect in port reservoir and decrease flow efficiency. • Requires a trained nurse to access and deaccess • Not available in triple lumen
Temporary apheresis or hemodialysis catheter	<ul style="list-style-type: none"> • Can be inserted at the bedside when immediate access is required • Can be used immediately after placement • Can be used for both inpatient and outpatient therapy (Exception: temporary femoral catheters usually are not used in outpatients.) • Can be used for IV infusion therapy 	<ul style="list-style-type: none"> • Designed for short-term use • Requires catheter to be reguided frequently, such as every three to four days to every week • Increases incidence of catheter-related infection and sepsis • If inserted into femoral vein, cannot be used for hyperalimentation • Increased risk of catheter displacement because usually not sutured • Often restricted to use for hemodialysis or apheresis only
Tunneled apheresis or hemodialysis catheter	<ul style="list-style-type: none"> • Can be used immediately after placement • Can be used for both inpatient and outpatient short- or long-term therapy • Provides long-term access for apheresis or hemodialysis • Large internal diameter of catheter provides high flow rate. • Incidence of catheter-related infection is lower than with temporary catheters. 	<ul style="list-style-type: none"> • Insertion is a surgical procedure. • Thrombosis is more likely with polyurethane catheter. • Catheter-related infection or sepsis can occur. • Poor flow may occur because of technique used for catheter placement and rigidity of catheter material, which causes kinking of lumens.

(b) Within certain limitations of infusate, peripheral IVs can be used for blood sampling for many routine tests, including coagulation studies, with reliable results (Prue-Owens, 2006).

(c) No definitive guidelines exist on blood sampling from peripheral IVs; research still needs to be done in this area. Additionally, weighing the benefits and risks of safety, costs, and comfort to the patient may aid in decision making.

c) Vein selection (see Figure 2)

(1) The vein selected should be based on the type of fluid to be infused and the rate and duration of infusion. Ideal-

ly, it should not interfere with the patient’s comfort or mobility.

(2) Preferred sites

(a) Upper extremity veins in adults; these may include the superficial dorsal and metacarpal veins on the dorsum of the hand as well as the cephalic and basilic veins, and cephalic, basilic, and median veins on the upper arm (see Figure 2).

(b) Hand veins have a lower risk of phlebitis than veins on the wrist or upper arm (CDC, in press; Morris & Tay, 2008).

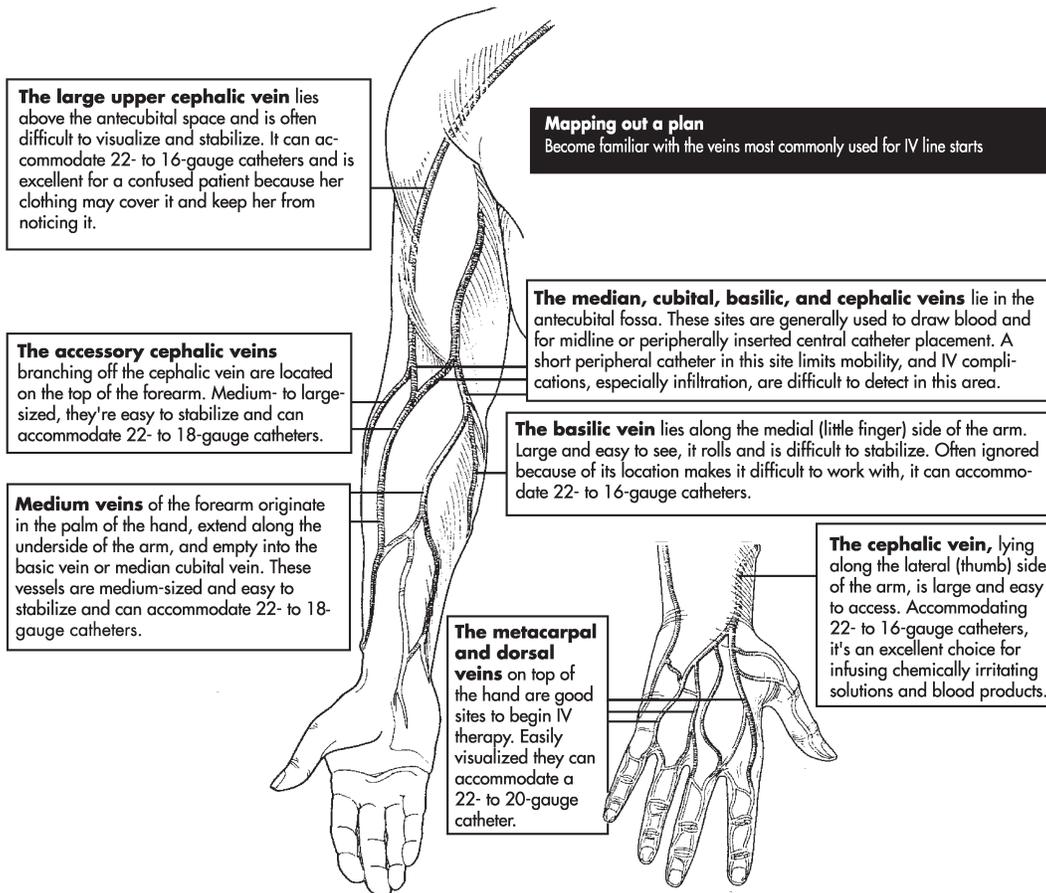
(c) Select the most distal site possible, but proximal to previous venipuncture.

- (3) Sites to avoid (Gabriel, 2008; Morris & Tay, 2008)
- (a) Avoid extremities/sites that have impaired circulation or injury, such as those with lymphedema, postoperative swelling, recent trauma, hematoma, axillary lymph node dissection, local infection, phlebitis, decreased sensation or paresthesia, or open wounds; also avoid extremities where venipuncture has been performed within the last 24 hours, if possible.
 - (b) Lower extremities are associated with higher risk of infection than are upper extremities (CDC, in press) and are more likely to develop thrombophlebitis. A physician order is recommended when using a lower extremity, but more importantly, nurses should consult

with a physician regarding central line placement or other alternatives prior to using the lower extremity. Replace the lower-extremity IV catheter as soon as it is feasible (CDC, in press).

- (c) Skin changes and changes in the integrity of the vein lumen associated with radiation, prior chemotherapy, or prior IV therapy can make catheter insertion or site care difficult.
- (d) Antecubital veins are not recommended because of the difficulty of detecting infiltration and because they are located on an area of flexion. In an emergency situation, the use of this large vein may be appropriate (Scales, 2008).
- (e) Avoid placing the cannula over a joint such as the wrist or elbow be-

Figure 2. Peripheral Venous Anatomy



Note. From "An Expert Answers Questions About Starting an I.V. Line," by A. Ellenberger, 1999, *Nursing*, 29(3), p. 57. Copyright 1999 by Lippincott Williams & Wilkins. Reprinted with permission.

- cause the movement of the joint may produce mechanical phlebitis and increase kinking of the catheter (Scales, 2008).
- (f) If possible, avoid venipuncture or IV insertion on extremities of a mastectomy site (Poage, Singer, Armer, Poundall, & Shellabarger, 2008).
- d) Catheter or device selection (Scales, 2008)
- (1) Use the smallest-gauge device and shortest length that will successfully deliver the prescribed therapy at the desired rate.
 - (2) Select catheter based on intended purpose, expected length of therapy, viscosity of fluid, fluid components, and condition of vein.
 - (3) Avoid use of steel needles for administration of fluids and medications that may cause tissue necrosis if extravasation occurs (CDC, in press); limit use of steel needles to short-term or single-dose administration or one-time infusion and IV push only.
 - (4) Considerations for gauge selection include the following (Scales, 2008).
 - (a) 16–18 gauge for major surgery
 - (b) 18–20 gauge for rapid infusion of IV fluids, blood components, or viscous medications
 - (c) 20 gauge for most IV applications and for blood products
 - (d) 22–24 gauge with 3/4-inch catheter for older adult and pediatric patients. Short length and small gauge is less traumatizing, reduces irritation, and permits better blood flow; 24 gauge can infuse up to 250 ml of fluid per hour.
 - (5) Obese patients with veins deep in the SC tissue may need slightly longer peripheral IV catheters, or a PICC may be considered as the catheter of choice.
 - (6) Risk of chemical phlebitis (irritation of the vein wall by medications) is reduced with good blood flow past the cannula to disperse the drug into the bloodstream.
4. Overview of insertion techniques (Gabriel, 2008; Morris & Tay, 2008; Scales, 2008)
- a) Perform patient assessment and preparation before the procedure; consider any special needs regarding age, physical condition, or type of fluid being infused. Explain the insertion procedure to the patient, and answer any questions the patient and significant others may have.
- (1) Older patients have fragile veins and less SC support tissue because of thinning of the skin.
 - (2) Use minimal tourniquet pressure over clothing or no tourniquet with older adults. Venous distention may take longer because of slower venous return.
 - (3) Children's veins are smaller in diameter and may be covered by a layer of SC fat, which can make veins difficult to access.
 - (4) Access sites for infants and toddlers may include the scalp and feet. Older children usually use the hands and arms.
- b) Consider interventions to reduce the pain of IV insertion, especially if they increase the chance of success. Interventions include topical anesthetics, injections, and nonpharmacologic techniques.
- (1) An order from a healthcare provider is needed for any pharmacologic intervention.
 - (2) Topical anesthetics include creams, patches, gels, and sprays (see Table 3).
 - (3) Dry heat has been found to be successful in IV insertion when compared to moist heat (Fink et al., 2009). Dry heated towels were used to wrap the upper extremity in a sample of 136 patients with hematologic cancer. Dry heat was more likely than moist heat to result in successful IV insertion on the first attempt and was more comfortable.
- c) Wash hands: Good hand hygiene and standard precautions are used for insertion and IV maintenance; a new pair of disposable, nonsterile gloves are used in conjunction with a "no-touch" technique for peripheral IV insertion.
- (1) With no-touch technique, the planned IV insertion site is not palpated after skin cleansing, unless sterile gloves are worn.
 - (2) Aseptic no-touch technique aims to prevent microorganisms on hands, surfaces, or equipment from being introduced to the IV insertion site.
 - (3) Wash hands before and after IV catheter insertion and dressing change (CDC, in press).

- d)* Organize equipment (see Appendix 2 for peripheral IV clinical practicum).
- (1) Prepare IV fluid, attach administration set, and prime if peripheral IV is to be connected to continuous fluids.
 - (2) If using peripheral IV for bolus medication administration, prepare IV medication and check for accuracy.
 - (3) If using peripheral IV as a saline lock, obtain protective cap and normal saline flush.
- e)* Examine veins on both extremities by visual inspection and palpation, keeping in mind the purpose of the IV therapy and any physical limitations of the patient, such as a stroke limiting the use of an arm or the side of an axillary node dissection. Assess distal veins, and then move proximally.
- (1) The Vein Entry Indicator Device (VEID™, Vascular Technologies) has been used with success in infants and children who can be technically challenging with small vein size (Simhi, Kachko, Bruckheimer, & Katz, 2008). VEID attaches to the distal end of an IV cannula with a standard Luer connection. An audible sound indicates when the needle penetrates the blood vessel, which reduces the risk of going through the vein.
 - (2) Other techniques used to locate and insert a peripheral IV include ultrasound guidance, which requires special training.
- f)* Place tourniquet 5–6 inches above insertion site. Tourniquet should obstruct the venous flow, not the arterial flow. Check presence of distal pulse, and if not felt, loosen the tourniquet. Tourniquets are for single use.
- (1) Select site. To assist in palpating a vein lightly, tap the vein, apply local warming, or have the patient hang arm downward (Simhi et al., 2008).
 - (2) Remove tourniquet for patient's comfort.
 - (3) If a large amount of body hair is present at the insertion site, clip the area. Avoid shaving, which can increase irritation and risk of infection (INS, 2006).
- g)* Select appropriate IV needle or catheter. Administer local anesthetic as needed (see Table 3).
- h)* Cleanse site and allow it to dry before inserting catheter (see Table 2). Chlorhexidine 2% is recommended for skin cleansing prior to IV insertion (Morris & Tay, 2008; Pratt et al., 2007). If patient is known to have an allergy to chlorhexidine, 70% alcohol or povidone-iodine can be used. Allow to dry before inserting the catheter.
- i)* Reapply tourniquet, and put on disposable gloves.
 - j)* Perform venipuncture. Insert needle at 15°–30° angle with bevel up distal to actual site of venipuncture.
 - k)* Look for blood return through tubing of butterfly needle or catheter, which indicates that needle has entered the vein. A butterfly needle may be taped in place at this time or threaded into the vein. An IV catheter should be threaded in its entirety into the vein and the stylet removed.
 - l)* Release tourniquet, and attach catheter to infusion set or syringe.
 - m)* Flush the catheter free of blood while holding the IV catheter or needle in place. Watch insertion site during initial flush to assess the integrity of the vein. Edema or pain/discomfort at the site indicates an infiltration or ruptured vein. If this occurs, remove the IV and restart it elsewhere.
 - (1) If the IV must be restarted, use the other extremity or select a site proximal to the previous venipuncture.
 - (2) When administering a vesicant chemotherapy agent, select a site on the opposite extremity, if possible.
 - n)* Secure IV catheter or needle with tape or a securement or stabilization device, and apply occlusive dressing over the insertion site. Do not put tape directly over the insertion site (Frey & Schears, 2006).
 - (1) Use of transparent, semipermeable dressings is recommended and results in significantly fewer dislodged catheters, with a trend toward reduced phlebitis and infiltration compared to gauze dressings.
 - (2) StatLock, a securement device, significantly reduced dislodgment episodes and increased dwell times of peripheral IVs.
 - (a)* Three securement methods were evaluated to determine which method could extend the average peripheral IV time.
 - (b)* The study demonstrated the following methods to secure the catheter: nonsterile tape, which resulted in a peripheral short catheter

survival rate of 8%; HubGuard® (Centurion Medical Products), which resulted in a 9% rate; and StatLock, which resulted in a 52% rate (Smith, 2006).

- (c) Other securement devices are available (Frey & Schears, 2006; Smith, 2006).
- (3) For extremely short dwell times, less than 30 minutes during a procedure, micropore tape could be used, but it should be clean and not in contact with the insertion site.
- o) No more than two attempts at cannulation per nurse per patient should be done to avoid unnecessary trauma to the patient. If possible, use the opposite arm to select a vein. If not possible, select a site proximal to the first venipuncture (INS, 2006; Lavery & Smith, 2007; Polovich et al., 2009).
- p) Document the number of attempts, location, type of catheter, gauge of catheter, dressing type, securement, and patient's response after procedure is completed.
- 5. Removal technique: Change peripheral catheter every 72–96 hours or earlier for signs of phlebitis or infiltration (CDC, in press; Gabriel, 2008; Lavery & Smith, 2007; Scales, 2008). Catheter should be removed when no longer required for therapy.
 - a) Verify order for removal and indication.
 - b) Explain procedure to patient.
 - c) Place patient in chair or bed to stabilize extremity.
 - d) Inspect general condition of catheter pathway.
 - e) Discontinue all infusions into the device.
 - f) Put on gloves; remove dressing; and observe site for any pain, edema, redness, or discharge.
 - g) Change gloves; pull catheter out in the same angle of insertion while stabilizing the skin and vein with sterile gauze.

- h) If removal of catheter is indicated for infection, send catheter tip for culture per order (INS, 2006).
- i) Apply constant, firm pressure to exit site until bleeding stops (longer in patients with coagulopathies or on anticoagulants). Apply dressing or adhesive bandage, and monitor as necessary.
- j) Instruct patient/caregiver to report any discomfort or signs of bleeding, bruising, redness, swelling, or drainage.
- k) Inspect device for defects. Report any defects to the manufacturer and regulatory agencies. Examine distal tip for signs of jagged, uneven edges suggestive of breakage.
 - l) Document observations and actions.
- 6. Maintenance and care (ASHP Commission on Therapeutics, 2006; CDC, in press; Gabriel, 2008; Prue-Owens, 2006; Scales, 2008) (see Table 1 for common maintenance procedures)
 - a) Inspect catheter insertion site and palpate for tenderness daily through the intact dressing (CDC, in press). Manipulation of the catheter should be kept to a minimum to prevent mechanical phlebitis (Scales, 2008).
 - b) All catheters inserted under emergency conditions are replaced within 48 hours when adherence to aseptic technique cannot be ensured (CDC, in press).
 - c) Routine replacement of catheters: A new catheter is placed in another site, and old catheter is removed.
 - (1) Replacement of peripheral IV catheters every 72–96 hours is strongly recommended to prevent phlebitis and catheter-related infections, as well as patient discomfort. This recommendation is based on experimental, clinical, or epidemiologic studies with a strong theoretical rationale (CDC, in press).
 - (2) Although the incidence of thrombophlebitis and bacterial colonization of catheters has been reported to increase when catheters are left in place for more than 72 hours (CDC, in press), several studies have shown no difference in complication rates with extended dwell times.
 - (a) In a study of the use of 665 catheters in 451 patients, the rate of phlebitis was 19.7% without a demonstrated increased risk for catheters remaining in place after three days (Bregenzer, Conen, Sakmann, & Widmer, 1998).

- (b) In a study of 722 patients, restarting the IV after 72 hours did not reduce the risk of complications when compared to continuing the original catheter (Homer & Holmes, 1998).
 - (c) No difference in phlebitis rates was shown for dwell times of 72 hours versus 96 hours in a study involving 2,503 catheters (3.3% and 2.6%, respectively) (Lai, 1998).
 - (d) When 34 catheters were left in place for more than 72 hours (73–120 hours), no phlebitis was detected (White, 2001).
 - (e) Of 1,161 catheters examined in another study, the overall phlebitis rate was 3.7%. It was recommended that if phlebitis is not present at 72 hours, continued assessment of the site may be more cost-effective and cause less discomfort for the patient than restarting the peripheral IV (Powell, Tarnow, & Perucca, 2008).
- d) Dressing: Change transparent dressing when catheter is changed providing the dressing is intact, clean, and dry. Change gauze and tape dressing every two days or as needed if wet, soiled, or nonocclusive. Dressing changes require an aseptic no-touch technique.
- e) Flushing: 0.9% normal saline 1–3 ml every 8, 12, or 24 hours when device is not in use to maintain patency (ASHP Commission on Therapeutics, 2006)
- f) All devices added onto the catheter should be Luer lock, including needleless connectors, stopcocks, short extensions, filters, injection caps, and multisite connectors.
- (1) Connections should be used only when necessary, as these are entry portals for infection.
 - (2) Devices should be changed when IV catheter is changed or when no longer intact.
 - (3) All IVs and equipment should be labeled with date and time to serve as a reminder of the need to change.
 - (4) Needleless connectors allow for IV administration without the use of a needle, thus reducing the risk of needlestick. These devices also ensure the IV system remains closed. These devices can be left in place until the catheter is changed (Scales, 2008).
- g) Blood specimens: Blood discard of 0.5–1 ml; obtain specimen and flush with 3 ml of normal saline. With different brands of peripheral IVs, saline locks, and extension sets, standardization of the amount of blood discard and flush is difficult. Prior to policy development, the dead space volume of the products used must be known.
- h) Bolus injections: Cleanse injection cap, allow solution to dry, infuse over a short period of time (usually 3–5 minutes), and flush with 1–3 ml of normal saline.
- i) Intermittent infusions: Used for drugs that require dilution or slow administration. Cleanse injection cap, allow solution to dry, infuse over specified time, and flush with 1–3 ml of normal saline.
- j) Continuous infusions: Most common method of administering IV fluids, drugs, and IV nutrition
7. Complications (Lavery & Smith, 2007; Polovich et al., 2009)
- a) Insertion complications include bleeding, vein injury, nerve injury, infiltration, phlebitis, and thrombosis.
 - b) Risk of vein injury from catheters can result in pain, tenderness, edema, redness (vasodilation), thrombosis, sclerosis, and infiltration.
 - c) Prevention of the most common complication, phlebitis, is related to having sufficient vessel size to accommodate the catheter and allow hemodilution, having a non-traumatic insertion, and infusing nonirritating solutions.
 - (1) Phlebitis most commonly occurs with prolonged dwell time and from mechanical or chemical irritation; risk increases with age and with irritating infusates (Powell et al., 2008; Scales, 2008).
 - (2) Signs and symptoms are pain, erythema, and edema.
 - (3) Older patients may not experience pain from phlebitis or infiltration because of a decrease in sensory perception; monitoring for complications through observation is important.
 - d) Infiltration is a common complication.
 - (1) Signs and symptoms include leaking fluid around insertion site, cool and pale skin, possibly decreased infusion rate, and skin tightness or discomfort.
 - (2) Assess for infiltration by occluding the vessel at the tip of the catheter with

digital pressure. If the infusion continues, the fluid is probably infiltrating.

- (3) Use of appropriately sized syringes will prevent vein rupture or infiltration with IV push administration or a vacuum on blood aspiration.
 - (a) The larger the syringe, the less pressure is generated when force is applied; the larger the syringe, the more force is required to create a vacuum. Thus, less force is generated in either infusion or aspiration with larger syringes, thereby reducing or preventing complications.
 - (b) A 1 ml syringe is not recommended for use with peripheral IV catheters. A 3 ml size is recommended for all flushing and administration of medications.
- e) Infection
 - (1) Infection can occur through a peripheral IV by the external catheter upon insertion, the interior of the catheter, contamination of connectors, or palpation of a proposed puncture site prior to IV insertion or by contaminated infusion (Lopez et al., 2009; Morris & Tay, 2008).
 - (2) Peripheral IVs rarely are associated with bloodstream infections.
 - (3) The reported rate of bloodstream infections attributed to peripheral IVs is 0.5% per 1,000 catheter days (Maki, Kluger, & Crnich, 2006).
 - (4) Use strict aseptic technique for insertion and maintenance care.
8. For a practicum on peripheral IV insertion and care, see Appendix 2.
9. Education and documentation (see Section X)
- C. Midline catheters
 1. Description and types
 - a) Catheter material: Silicone or polyurethane (Hadaway, 2010)
 - b) Available as radiopaque, latex free, or with closed-valve tip
 - c) Available in single and double lumens
 - d) Range from 2 Fr (23 gauge) to 6 Fr (18 gauge)
 - e) Range from 3–8 inches in length
 - f) Prime volume of 0.5–1.5 ml
 - g) Considered a peripheral line because the tip is not located in the central circulation
 - h) Considered a midline when the catheter terminates at the axillary vein in the up-

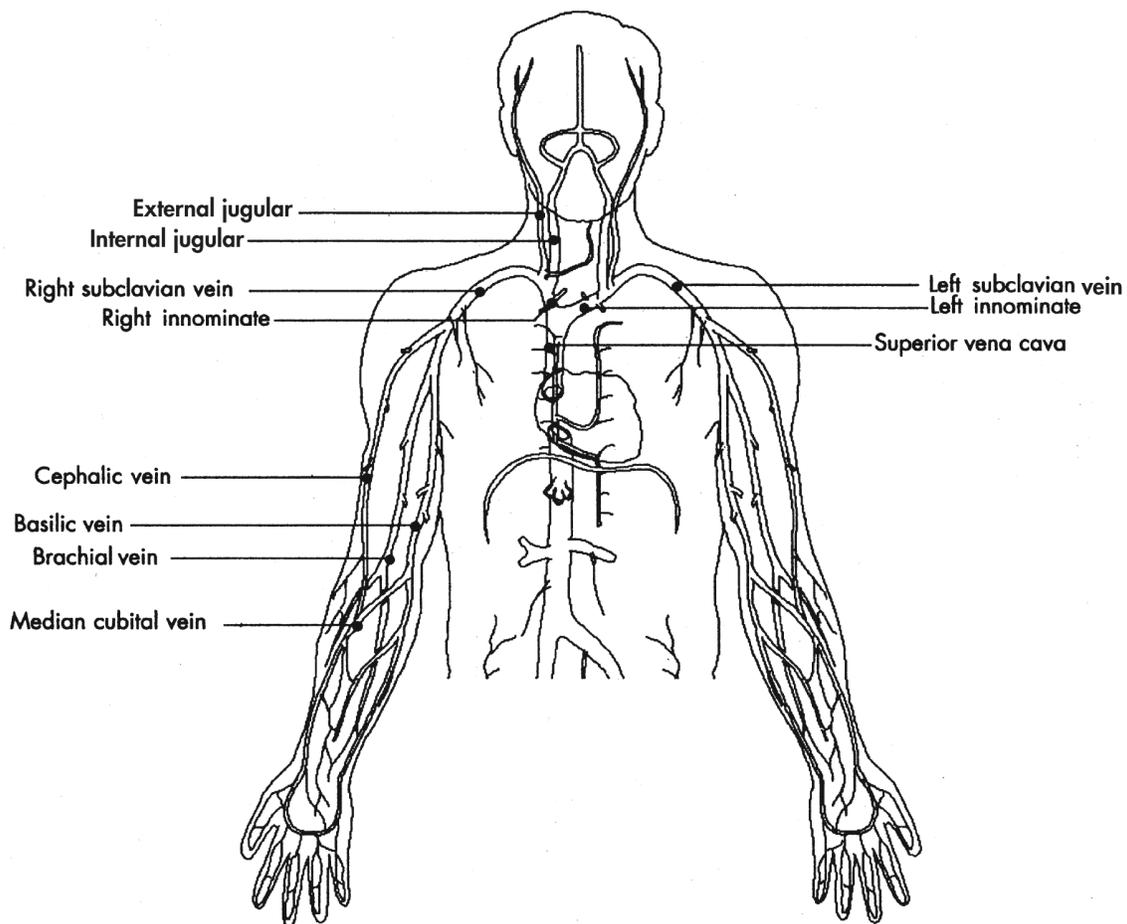
per arm (Gallieni et al., 2008; Polovich et al., 2009)

- i) Approximate cost: \$75
2. Advantages and disadvantages: See Table 4.
3. Patient selection criteria
 - a) Patients with limited peripheral veins for venous access
 - b) Patients with need for venous access for a limited length of time (one to four weeks)
 - c) Patient or caregiver is willing and able to understand and follow instructions on how to properly care for the device in the home setting.
 - d) IV therapy planned is appropriate for midline catheter. Contraindicated IV fluids include (Perucca, 2010)
 - (1) Continuous infusion of vesicants
 - (2) Solutions with glucose concentration greater than 10%
 - (3) Solutions with protein concentration greater than 5%
 - (4) Solutions with osmolarity greater than 600.
 - e) Patient preference for this type of device over more permanent devices
 - f) Limited life expectancy of the patient
 - g) For patients scheduled to receive IV therapy for more than a week, a plan should be followed to maximize comfort and preserve the integrity of the veins.
 - h) An extremity affected by a mastectomy, lymph node dissection, or lymphedema is not appropriate for midline catheter insertion (Hadaway, 2010).
4. Insertion technique
 - a) Insert in an antecubital vein terminating in the upper arm or axilla (see Figure 2). Appropriate veins include
 - (1) Basilic
 - (2) Cephalic
 - (3) Median cubital.
 - b) Determine if the patient is a suitable candidate for a midline catheter based on patient selection criteria and patient's willingness to care for and protect a catheter.
 - c) Explain the procedure to the patient and answer any questions the patient or significant others may have.
 - d) Organize equipment and wash hands.
 - e) Examine veins on both extremities, taking into account the purpose of the IV therapy, the most comfortable exit site for the patient, and any physical limitations the patient may have, such as stroke or lymphedema, that could limit the use of one arm.

- f) Use local anesthetic (topical, injectable) per institutional policy and patient preference. Be aware that anesthetic may obscure the vein secondary to vasoconstriction and vasospasm. An order from a healthcare provider is needed (see Table 3).
 - g) Place the line per manufacturer's guidelines for the type of catheter being used; the nurse inserting should be trained for the individual product.
 - h) Anticipate insertion site to be 1–1.5 inches above or below antecubital fossa. Extend patient's arm, and abduct the arm at a 45° angle.
 - i) Place tourniquet 5–6 inches above insertion site at the mid-upper arm area. Tourniquet should obstruct venous, not arterial, flow. Check presence of distal pulse. Remove tourniquet for patient's comfort.
 - j) Clip the area if a large amount of body hair is present at insertion site. Avoid shaving, which can cause increased irritation and risk of infection.
 - k) Cleanse site, and allow to dry. Reapply tourniquet. Apply sterile gloves. Drape arm with sterile drapes for sterile field. Flush catheter with 0.9% sodium chloride solution.
 - l) Stabilize vein below access site with non-dominant hand. Perform venipuncture by inserting needle at a 15°–30° angle with bevel up distal to actual venipuncture site.
 - m) Look for blood return through tubing of catheter, which indicates that the needle has entered the vein. Advance to length of needle, and remove tourniquet.
 - n) Once venipuncture is complete, retract the needle into the needle safety tube on the external end of the catheter. The tip of the catheter is advanced slowly for several inches to the desired initial length through the introducer. Remove guidewire slowly while stabilizing midline catheter at insertion site. Remove introducer, and break away or peel away from catheter by pulling apart at wings. Flush with normal saline.
 - o) Secure IV catheter with tape, stabilizing device, or securement device, and apply dressing over insertion site.
 - p) The dressing should be changed 24 hours after insertion to assess for complications, and then per protocol for transparent film or gauze dressing.
 - q) Because a midline catheter is not considered a central catheter, x-ray verification of tip placement is not indicated.
 - r) Document insertion, including type of line used, length of catheter, and patient tolerance.
5. Removal technique
- a) Verify order for removal and indication.
 - b) Explain the procedure to the patient and answer questions.
 - c) Place the patient in a reclining position.
 - d) Inspect the general condition of the catheter.
 - e) Discontinue all infusions into the device.
 - f) Put on gloves, remove dressing, and observe site for redness, swelling, bruising, or drainage.
 - g) If drainage is present, send swabs for culture with provider order.
 - h) Change gloves.
 - i) Grasping device by the hub, pull slowly and steadily until completely removed from patient.
 - j) If infection is suspected, send catheter tip for culture.
 - k) Apply constant firm pressure to the exit site until the bleeding has stopped (longer in patients with coagulopathies or decreased platelet count). Apply sterile occlusive dressing, and monitor for bleeding or drainage.
 - l) Measure catheter for appropriate length and catheter integrity. Examine distal tip for jagged edges that would suggest breakage. If found, report to physician.
 - m) Document length of catheter on removal, action, and patient response.
6. Maintenance and care (see Table 1) (Gorski & Czaplowski, 2004)
- a) Dwell time: One to eight weeks
 - b) Dressing: Transparent dressing changed every seven days. Gauze and tape dressing changed every two days or as needed if wet, soiled, or nonocclusive.
 - c) Flushing: Normal saline 1–3 ml every 8, 12, or 24 hours

- d) Cap change: Every week or with catheter change
 - e) If the catheter is used for blood draw: Discard 0.5–1 ml of blood, obtain specimen, and flush with 3 ml normal saline.
7. Complications: See Sections II.B and II.I.
 8. Education and documentation: See Section X.
 9. Special considerations for pediatrics
 - a) Available in 24- and 22-gauge sizes
 - b) Lengths range from 3–6 inches.
 - c) Patients who need venous access for a limited length of time (approximately one to eight weeks)
 - d) Appropriate for administration of IV fluids, blood products, and medications
 - e) Midline catheter insertion sites include the basilic and cephalic vein in the upper extremity, the saphenous and femoral vein in the leg with the tip below the groin and away from flexion areas, and the temporal scalp vein or the external jugular.
 10. Special consideration for older adults (Moureau, 2008): Avoid tourniquet use in older adults with fragile veins and thin skin.
- D. Nontunneled central venous lines
1. Description and types
 - a) Catheter material: Silicone or polyurethane
 - b) Available options: Latex free, radiopaque, antimicrobial impregnated, and heparin impregnated (Gallieni et al., 2008)
 - c) Range from 14–24 gauge in single-lumen and multilumen designs
 - d) Distal tip openings are open or valved (Groshong-type).
 - e) Distal tip openings on multilumen catheters may be side-by-side or staggered.
 - f) Power line available to allow for power injection of contrast media at an infusion rate of 5 ml/s.
 2. Advantages and disadvantages: See Table 4.
 3. Patient selection criteria
 - a) Size of patient/vein may determine the gauge of catheter and number of lumens used. Catheters of the smallest gauge necessary for indicated therapy should be placed to decrease the incidence of venous thrombosis (Gallieni et al., 2008).
 - b) Patients receiving short-term treatment (up to six weeks) with no need for extended therapy anticipated (Gabriel, 2008)
 - c) Patients with poor peripheral venous access
 - d) Patients who require treatment with fluids that are hyperosmolar, alkaline, or acidic (Gabriel, 2008)
 - e) Patients who require frequent venous access for infusion or blood specimens
 - f) Poor surgical candidates for long-term catheter placement
 - g) Critically ill patients requiring multilumen access or central venous pressure monitoring (Gabriel, 2008)
4. Insertion location (see Figure 3). Healthcare professionals specifically trained can insert. Refer to individual state board of nursing for regulations.
 - a) Preferentially, use the right internal jugular vein as the entry site because it follows a fairly straight course to the subclavian. A triangle of landmarks (clavicle and the two heads of the sternocleidomastoid muscle) identifies the insertion site.
 - b) Cannulate the subclavian vein on the left side, if possible, because it has a smooth curve to the superior vena cava without an acute turn.
 - c) If the right internal jugular is not available, the left internal jugular, the external jugular, or the subclavian veins may be used (Weigand & Carlson, 2005). The following conditions may require use of the affected side, or even femoral placement of the central venous catheter (Gabriel, 2008).
 - (1) Enlarged axillary or subclavian nodes
 - (2) Tumor mass
 - (3) Previous surgery or radiotherapy to the axillary or subclavian area
 - (4) History of previous thrombosis
 - (5) Presence of cardiac pacemaker
 - d) Femoral insertion with the tip in the inferior vena cava is possible but has an increased risk of infection and thrombotic complications (Marschall et al., 2008).
 5. Insertion techniques (Marschall et al., 2008; Weigand & Carlson, 2005)
 - a) Perform a preplacement assessment of the patient to determine if a nontunneled catheter is appropriate, based on patient selection criteria.
 - b) Explain the insertion procedure to the patient and answer any questions the patient or significant others may have. Ensure that informed consent is obtained. Determine if the patient has allergies to iodine or tape products, and inform the practitioner placing the line.
 - c) Position the patient
 - (1) Usually, the patient is placed in a 15°–25° Trendelenburg position, which distends the vein selected for cannula-

Figure 3. Venous Anatomy



tion and decreases the risk of air embolism.

- (2) If the internal jugular is to be used, the patient's head should be turned to the opposite side of the catheterization to decrease contamination and make the site more accessible.
 - (3) A rolled towel may be placed beneath the patient's neck and shoulders to increase venous distention.
- d)* Use of maximal sterile barrier precautions, including mask, cap, sterile gown, and sterile gloves, by all practitioners involved with the insertion procedure and draping of the patient with a large drape are essential to reduce infection risk.
- e)* Prepare the insertion site with a chlorhexidine-based cleansing agent, provided the patient is older than two months of age (see Table 2) (Marschall et al., 2008). If necessary, clip (do not shave) long hair to decrease contamination.

f) Use local anesthetic to decrease insertion discomfort (see Table 3).

g) Use of ultrasound guidance for cannulation has been shown to reduce complications, the number of failed attempts, and the time required for insertion (Gallieni et al., 2008; Hind et al., 2003). Insert needle percutaneously into the vein with a stylet and guidewire, using the clavicle as a guide.

- (1) When a flashback is observed in the syringe, the syringe is removed, and a guidewire is advanced into the vein. The guidewire should not be advanced farther than 18 cm in order to minimize complications.
- (2) The catheter is advanced over the guidewire into the subclavian vein until it reaches the superior vena cava.
- (3) The guidewire is removed.

h) Flush each lumen with saline.

i) Avoid suturing; secure catheter with tape, securement device, or stabilization device,

and then apply an occlusive dressing over the exit site (CDC, in press).

- (1) SecurAcath™ (Interrad Medical) utilizes a very small anchor that deploys under the skin to hold catheter in place.
 - (2) Newer method for holding nontunneled catheters in place without suturing
- j)* Obtain radiographic confirmation before therapy is initiated to determine proper placement and location of the tip, and to detect pneumothorax, although there is a low incidence of complications following subclavian or nontunneled central line placement (Gabriel, 2008). Tip placement should be in the distal third of the superior vena cava.
 - k)* Allow a healthcare provider to verify the proper position in the superior vena cava; then the line may be used immediately for infusion.
 - l)* Document length of catheter, presence of blood return, and condition of patient.
6. Removal of device
- a)* Nontunneled lines are removed when therapy is completed, when the line is no longer functional because of thrombus or mechanical failures, or when the line is infected.
 - b)* Routine replacement of a nontunneled central catheter should not be performed (CDC, in press).
 - c)* Verify order for removal and indication.
 - d)* Note the length of the catheter on insertion.
 - e)* Explain the procedure to patient.
 - f)* Place patient in a reclining position.
 - g)* Inspect the general condition of the catheter.
 - h)* Discontinue all infusions into the device.
 - i)* Put on gloves, remove dressing, and inspect exit site for redness, pain, swelling, exudate, or other problems.
 - j)* Change gloves and remove sutures, if present.

- k)* Have patient perform Valsalva maneuver (Weigand & Carlson, 2005). Performing the Valsalva maneuver decreases the risk of air embolism during catheter removal. The maneuver is contraindicated in patients with increased intracranial pressure and those who are intubated.
 - (1) Instruct patient to take a deep breath and hold it.
 - (2) Patient should “bear down” for 10 seconds.
 - (3) Patient then exhales.
 - l)* Grasp the hub of the nontunneled catheter, and gently and steadily retract catheter until completely removed from patient.
 - m)* Apply constant, firm pressure to the exit site until bleeding stops (longer in patients with coagulopathies or decreased platelet count). Apply sterile, occlusive dressing, and monitor patient for discomfort, bleeding, bruising, redness, swelling, or drainage. Advise patient and family to report any of these signs.
 - n)* Visually inspect VAD for appropriate length and defects, such as holes, tears, or jagged edges suggesting breakage. If length is shorter than expected or the edges appear broken, notify the physician.
 - o)* Document observations, actions, and patient teaching.
7. Maintenance and care (see Table 1)
- a)* Dwell time: Short-term catheters, approximately up to six weeks
 - b)* Dressing: Dressing changed 24 hours after insertion
 - (1) Transparent dressing changed every five to seven days
 - (2) Gauze and tape dressing changed every two days or as needed if wet, soiled, or nonocclusive
 - c)* Flushing: Heparin 10–100 IU/ml: 2–3 ml/day per each lumen. May heparin lock after use for intermittent infusions after flushing with normal saline.
 - d)* Cap change: Every week or if no longer intact
 - e)* For blood specimens: Discard 1–2 ml of blood; flush with 10–20 ml of normal saline.
8. Complications (see Section II.I): Potential complications related to central line removal include venous air embolism, dyspnea, pain, bleeding from the insertion site, and arrhythmias (Weigand & Carlson, 2005).
9. Education and documentation: See Section X.

10. For a practicum on short-term venous catheter care, see Appendix 3.

E. PICCs

1. Description and types (Hagle, 2007)

- a) Catheter material: Silicone, polyurethane, or elastomeric hydrogel
- b) Range from 16–28 gauge in single- and double-lumen designs; pediatric sizes range from 24–28 gauge in single- and double-lumen designs.
- c) Lengths range from 15–27 inches.
- d) Prime volume of 0.5–1.5 ml
- e) PowerPICC® (C.R. Bard, Inc.) catheters are now available for the delivery of power injection flow rates required for contrast-enhanced injections.
- f) PICCs are available with PASV on 3 Fr catheters.
- g) Radiopaque is available for PICCs.
- h) Cost: Approximately \$714–\$985, excluding cost of radiology confirmation

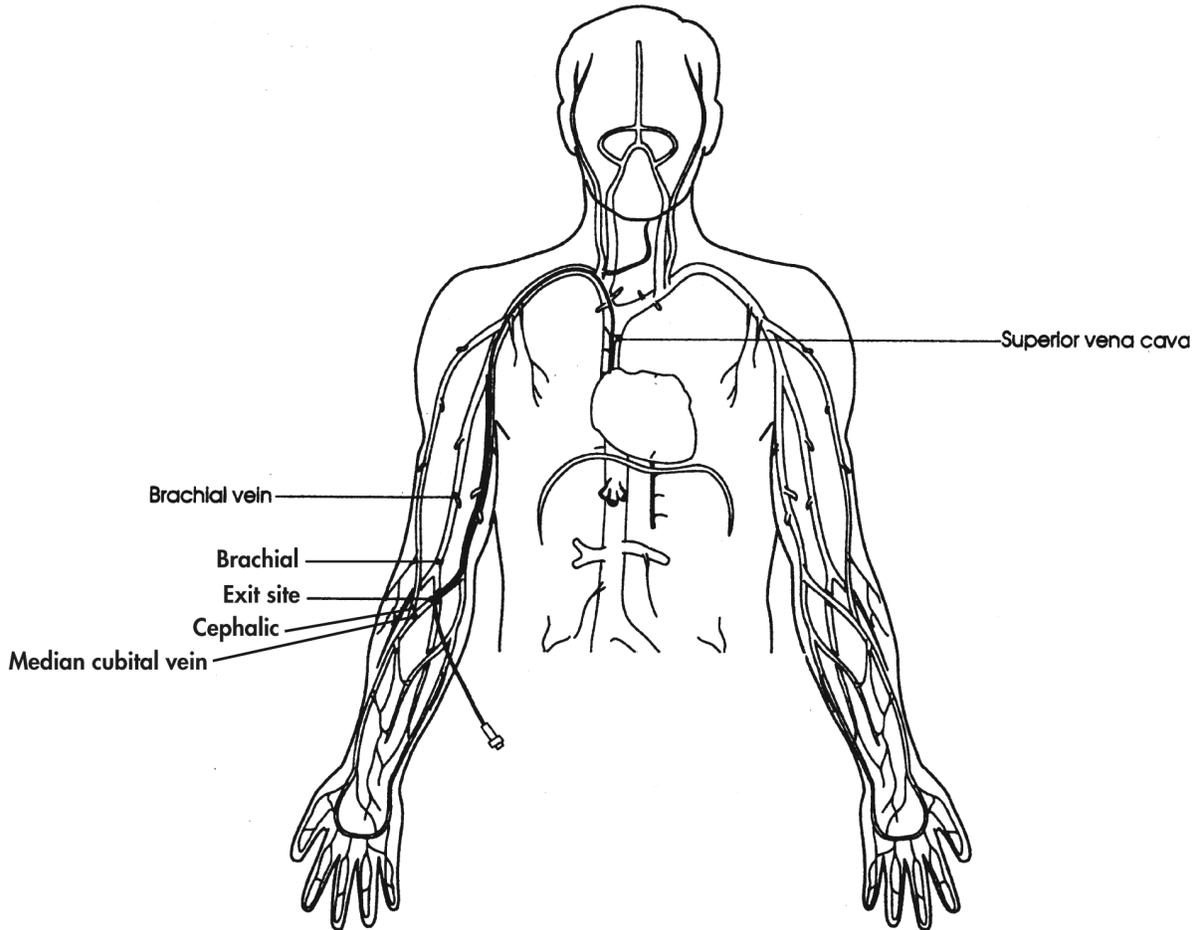
2. Advantages and disadvantages: See Table 4.

3. Patient selection criteria (Gallieni et al., 2008; Hagle, 2007)

- a) Patients without accessible peripheral vessels or with a minimal number of adequate vessels available for use in the administration of therapy for moderate duration (three to six months); however, the FDA has approved the use of PICCs for up to 12 months (Gallieni et al., 2008). There is no established dwell time (the maximum expected duration considered appropriate for a given type of device) for PICCs (CDC, in press).
- b) Patients who are in need of vesicant or irritating medication infusions
- c) Patients who are in need of hyperosmolar solution infusions, such as TPN
- d) Patients who prefer this type of device over other VADs that may be equally appropriate for the situation
- e) In the home setting, patients who have a family member or significant other who can properly care for the device
- f) For patients scheduled to receive IV therapy for more than five days, a plan should be followed to maximize comfort and preserve the integrity of the veins.

4. Insertion techniques (Hagle, 2007): Appropriate tip location for a PICC is the distal third of the superior vena cava (Gallieni et al., 2008; Hamilton, 2006). Only healthcare professionals who have successfully completed a PICC insertion course should insert PICCs. This course is beyond the scope of these guidelines.

- a) Insert PICCs via the vein (see Figure 4).
 - (1) Cephalic
 - (2) Accessory cephalic
 - (3) Basilic
 - (4) Median cubital
 - (5) Pediatric considerations for insertion: Conscious sedation may be considered (Mickler, 2008; Pettit, 2007).
 - (a) Three months of age: Superficial temporal, posterior auricular, saphenous, or median cubital veins
 - (b) Four months of age until ambulatory: Saphenous, cephalic, basilic, or median cubital veins
 - (c) Ambulatory child: Basilic, cephalic, brachial, or median cubital veins
 - (6) Special considerations for insertion in older adult patients (Moureau, 2008): Avoid tourniquet use in those with fragile veins and thin skin.
- b) Perform a preplacement assessment of the patient to determine if a PICC is appropriate.
- c) Choose appropriate PICC size (diameter) for solution to be administered. Use the smallest acceptable catheter diameter to decrease incidence of thrombophlebitis (INS, 2006).
- d) Explain the insertion procedure to the patient and answer any questions the patient or significant others may have. Ensure that informed consent is obtained.
- e) Gather all necessary supplies, including any IV administration sets and medications or IV fluids to be used.
- f) Wash hands with a cleansing agent.
- g) Examine patient's arms and select the best vein for cannulation.
 - (1) Avoid veins that are sclerotic on inspection and palpation.
 - (2) Select patient's nondominant arm, if possible.
 - (3) Avoid extremities that may have compromised circulation, such as those with the presence of lymphedema or venous congestion secondary to superior vena cava syndrome.
 - (4) If possible, the basilic vein would be the best choice, as it is the straightest and has the most direct route to the central venous system (Hagle, 2007).
 - (5) The cephalic vein is the second choice because its abrupt angle that joins to the axillary vein makes advancement

Figure 4. Peripherally Inserted Central Catheter Placement

of the line more difficult. Position the patient's arm at a right angle to the body to assist with insertion (Bullock-Corkhill, 2010).

- h)* Consider the use of a local anesthetic (topical cream or intradermal injection, see Table 3) to reduce the pain associated with insertion (Bullock-Corkhill, 2010). An order is needed from a healthcare provider with prescriptive authority.
- i)* Use a measuring tape to determine appropriate catheter length by measuring from the point of venipuncture, over the course of the selected venous pathway, across the shoulder to the right side of the sternal notch, and down to the third intercostal space. The tip of the catheter should rest in the superior vena cava (see Figure 4). Add 2.5 cm (1 inch) onto this measurement to account for the length of the catheter outside of the insertion site.

- j)* Open the PICC tray and, following sterile technique, add additional supplies. The general insertion procedure may vary according to the type of PICC being used. The RN needs to be familiar with the product selected and follow the manufacturer's directions.
- k)* Position the patient's arm at a 45°–90° angle from the body, below heart level, to aid in vein engorgement.
- l)* Perform catheterization with full sterile technique, including surgical hand scrub, mask, sterile gown, gloves, drapes, and appropriate cleansing agents (Bullock-Corkhill, 2010; INS, 2006).
- m)* Place sterile waterproof drape under patient's arm.
- n)* Cleanse the area and allow it to air-dry before initiating cannulation.
- o)* Fill two syringes with normal saline. Use one syringe to prime extension tubing that may be needed during the procedure.

- p)* Place fenestrated sterile drape (a sterile drape with an opened center) over the arm, leaving the insertion site exposed.
- q)* Prepare the catheter.
- (1) Measure the length of catheter needed, using the sterile measuring tape.
 - (2) Pull the guidewire back ½ inch from this distance.
 - (3) Trim the catheter with sterile scissors according to the manufacturer's recommendation. Some PICC manufacturers do not recommend trimming the catheter. Others recommend trimming at a 45° or 90° angle. Groshong PICCs are trimmed proximally and not at the distal tip.
- r)* Apply tourniquet approximately 4 inches above selected site. Check distal pulse to ensure that arterial circulation has not been compromised. Change sterile gloves.
- s)* While stabilizing the vein, perform venipuncture. Note blood return, which indicates introducer location inside the vein.
- t)* Release tourniquet, and continue to advance the catheter according to the PICC insertion technique.
- (1) Peel-away sheath technique: Venipuncture is made with a needle/sheath device. After the stylet is removed, the catheter is threaded into the vein, and the sheath/cannula is removed down to the hub of the catheter. Wings of the sheath/cannula are cracked, and the two sections are pulled apart and away.
 - (a)* Advantages: Risk of catheter damage is low, a variety of gauge sizes are available, and it can be performed virtually without blood spills.
 - (b)* Disadvantages: A larger introducer unit is required, as is the acquisition of a new skill (peeling away a sheath). It has a higher incidence of thrombophlebitis than the modified Seldinger method and may cause more bleeding around the exit site during the first few hours after insertion.
 - (2) Over-wire Seldinger method: Venipuncture is made with a smaller-gauge steel needle. Blood is obtained in the attached syringe. The syringe is removed, and a guidewire is threaded through the needle into the vein. The needle and cannula are removed, and a peel-away sheath is threaded down to the skin over the guidewire introducer. The guidewire is removed and the catheter is advanced, stabilized, and the sheath removed and torn away.
 - (a)* Advantages: Requires smaller venipuncture, a variety of gauge sizes are available, and the risk of catheter damage is eliminated.
 - (b)* Disadvantages: It is a more complex technique, the need for a minor surgical incision may limit its insertion in particular settings and by certain clinicians, and insertion costs more than other methods.
- (3) Placement of PICCs is guided with the use of ultrasound. Positioning systems are available to identify the placement of PICCs.
- (a)* The VasoNova™ Vascular Positioning System™ assists in accurate placement of a PICC. The technology uses Doppler technology with internal physiologic parameters to accurately guide PICCs into superior vena cava. Using this navigation system reduced supply and labor costs because of accuracy in insertion (Naylor, 2007).
 - (b)* The Sherlock™ II tip location system is designed for use with Bard Access Systems PICCs (C.R. Bard, Inc.). This system detects slight magnetic fields generated by the preloaded stylet to guide catheter into position. Audible or visual signals indicate the location of tip position.
 - (c)* Locater systems help to reduce risks associated with blind placement.

- u) Attach prefilled syringe, and flush with normal saline. Ensure adequate blood return. Primed extension tubing may be attached at this time.
 - v) After securing the catheter hub with tape, SteriStrips, or stabilizing or securement device, flush with heparin solution.
 - w) Apply dry, sterile gauze above insertion site, and place an occlusive dressing over the insertion site and external part of the catheter up to the hub. Change dressing 24 hours after initial insertion (likely to have bloody drainage), and apply only a transparent dressing. Several manufacturers have developed PICC line securing devices.
 - x) Radiographic confirmation must be performed to ensure correct placement. Some institutions may require that the guidewire be left in place to aid in PICC line verification during radiographic study because the small size of PICCs makes radiographic visualization difficult but possible. Extreme caution should be used during the radiographic study to prevent catheter puncture. Guidewires should not be left in place for a long period of time.
5. Removal technique: Ensure removal is in the scope of practice from individual state board of nursing.
- a) Verify order for removal of catheter.
 - b) Gather materials needed: measuring tape, alcohol pad, gauze, and tape.
 - c) Wash hands, and don nonsterile gloves.
 - d) Remove existing dressing. Remove contaminated gloves and replace.
 - e) Grasp PICC at the insertion site and slowly pull outward, about one inch, pulling parallel to the skin.
 - f) Release it and grasp again at insertion site, continuing to pull the PICC out in short increments.
 - g) When PICC is completely removed, place gauze over the site and apply light pressure until bleeding stops, then apply occlusive dressing. Change dressing in 24 hours and observe site. Apply dressing if needed.
 - h) Observe catheter tip for integrity, and measure length and compare it to the length documented at insertion.
 - i) Problems with removal
 - (1) Venospasm
 - (a) If you sense resistance during removal, stop. Reposition the arm and attempt to remove it again.
 - (b) If resistance continues, apply warm compress to upper arm for 15–20 minutes and attempt gentle removal again.
 - (c) If the catheter has been removed far enough so that you can apply a tourniquet above the area containing the catheter, apply the tourniquet to the arm, and attempt removal again.
 - (d) If resistance is still present, apply gauze and tape dressing to insertion site and leave alone for 12–24 hours and attempt removal again.
 - (2) Thrombosis
 - (a) Will cause the PICC to eventually lodge in the lumen of the vessel as you attempt removal
 - (b) If during removal you are only able to pull the PICC out four inches or less, stop.
 - (c) Because you do not know whether this is caused by venospasm or thrombosis, use interventions recommended for venospasm.
 - (d) If these attempts fail, notify physician for possible radiologic studies to rule out thrombus.
 - (3) Catheter fracture
 - (a) Catheters may be damaged prior to removal or may become damaged if excessive force is applied during the removal process.
 - (b) If the catheter breaks during removal but is still long enough to be pulled, clamp the catheter and continue removal.
 - (c) If the catheter breaks at the insertion site, clamp it and apply a tourniquet around the upper arm in an attempt to prevent migration of the fragment. The tourniquet should not impede the arterial flow; check radial pulse.
 - (d) Notify the physician immediately, as a cut-down procedure will be needed to extract the catheter.
 - (e) If a complete fracture occurs within the vein above the insertion site, immediately apply the tourniquet at the highest point on the arm.
 - (f) The fragment can become an embolus. Place patient in Trendelenburg position, and contact the physician immediately. Observe for

- shortness of breath, tachycardia, confusion, pallor, or hypotension. The fragment will need to be removed by an interventional radiologist, thoracic surgeon, or vascular surgeon.
6. Maintenance and care (see Table 1) (Bowe-Geddes & Nichols, 2005; Gorski & Czaplowski, 2004)
 - a) Dwell time: Approximately 12 months
 - b) Dressing: 24 hours after insertion. Transparent dressing changed every five to seven days. Gauze and tape dressing changed every two days, or as needed if wet, soiled, or nonocclusive. See Figure 5.
 - c) Flushing: Heparin 10–100 IU/ml: 3 ml/day or 3 ml/day three times a week
 - d) Cap change: Every week
 - e) For blood specimens: Discard of 1–2 ml of blood, flush with 10 ml normal saline
 7. Complications: See Section III.I.
 8. Education and documentation: See Section X.
 9. For a practicum on long-term VAD insertion and care, see Appendix 4.
- F. Tunneled central venous catheters (CVCs)

Figure 5. Peripherally Inserted Central Catheter Line



1. Description and types
 - a) Catheter material: Polyurethane, silicone, a combination of the two, or Bio-Flex® catheter (Medical Components, Inc.)
 - b) Lengths range from 35–100 cm (29.5–42.7 inches).
 - c) Range from 2.7–12.5 Fr in single-, double-, and triple-lumen designs
 - d) Internal diameters range from 0.5–1.6 mm.
 - e) Prime volume of 0.15–2 ml
 - f) Flow rate ranges from 49 ml/hr to approximately 3,500 ml/hr.
 - g) Types of catheter cuffs
 - (1) Dacron® (DuPont) cuff: Positioned in the SC tunnel 1–2 inches from the exit site
 - (a) The cuff allows fixation of the catheter to the SC tissue by becoming enmeshed with fibrous tissue, thus promoting the securing of the catheter. However, this does not guarantee that dislodgment will not occur.
 - (b) The cuff potentially minimizes risk of ascending infection from the exit site into the tunnel (CDC, in press).
 - (2) Antimicrobial VitaCuff® (Vitaphore Corp.)
 - (a) The device potentially creates another physical barrier for migration of bacteria.
 - (b) The device releases an antimicrobial agent for approximately four to six weeks or until the catheter is embedded into tissue.
 - (3) Radiopaque catheters: Tunneled catheters such as Groshong, Hickman, and dialysis/apheresis catheters visualized on radiographic imaging
 - h) Types of catheters
 - (1) Open-ended distal tip catheters: Require clamping for connection of IV tubing or syringes
 - (2) Closed-ended distal two-way pressure-sensitive valve tip catheters
 - (a) Catheters are available with PASVs located in the catheter hub.
 - (b) Clamping is not required because the valve remains closed except during infusion and aspiration.
 - (3) Power Hickman catheter available, allowing injection of contrast media for scans at maximum rate 5 ml/s and 300 psi limit.

2. Advantages and disadvantages: See Table 4.
3. Patient selection criteria: May be used in any patient population that requires long-term IV access, such as hematopoietic stem cell transplant (HSCT) recipients, those with hematologic disease, or those with malignant diseases requiring IV chemotherapy that will result in a prolonged nadir of blood counts.
4. Insertion technique: Surgical procedure by surgeon or interventional radiologist after informed consent is obtained
 - a) Select the vein according to the individual patient's anatomic structure, type and purpose of catheter, and the vessel used. The most common veins used for insertion include the following (see Figure 3).
 - (1) Subclavian vein
 - (2) Internal or external jugular vein
 - (3) Cephalic vein
 - (4) Femoral vein
 - b) Perform percutaneous insertion (Biffi et al., 2009).
 - (1) It is the most common insertion technique using the subclavian or internal jugular vein. Once the vein is cannulated, the guidewire is advanced into the vein.
 - (a) A pull-apart sheath introducer is threaded over the guidewire.
 - (b) The guidewire is removed, and the catheter is advanced through the introducer into the vein.
 - (c) The catheter is tunneled through the SC tissue. The tunnel is created from the vein entry site to the exit site. With the antegrade technique, the catheter is pulled from the exit site through the tunnel to the vein entry site and trimmed. With the retrograde technique, the catheter is pulled from the vein entry site to the exit site and trimmed.
 - (2) The exit site depends on male and female anatomy; however, usually it is above the nipple line midway between the sternum and clavicle.
 - c) Perform the cut-down insertion (Biffi et al., 2009).
 - (1) The procedure greatly reduces risk of hemothorax or pneumothorax.
 - (2) This technique is more time-consuming and difficult to perform than other methods.
 - (3) The procedure requires more manipulation of the skin and SC tissue, thereby increasing the infection rate.
 - (4) The veins used include the axillary, external jugular, internal jugular, cephalic, and subclavian.
 - d) Verify catheter position by radiographic imaging.
 - e) Secure catheter with sutures.
 - (1) Exit-site sutures remain in place until healing occurs, which can range from 10 days to 6 weeks or longer if immunosuppression is present.
 - (2) Sutures are removed after healing to prevent irritation and infection at the exit site.
 - (3) In some cases (e.g., the use of apheresis catheters), sutures are left in place until the catheter is removed because of the risk of catheter dislodgment caused by the external weight of the catheter.
5. Removal technique: RNs may be able to remove tunneled catheter, depending on their specific State Board of Nursing Practice Act.
 - a) Verify order for removal and indication.
 - b) Note length of catheter on insertion.
 - c) Explain procedure to the patient.
 - d) Place the patient in reclining position.
 - e) Inspect general condition of catheter and tunneled pathway.
 - f) Discontinue all infusions into the device.
 - g) Put on gloves, remove dressing, and observe site for edema, erythema, or other problems.
 - h) Change gloves and remove sutures as needed.
 - (1) Have the patient perform Valsalva maneuver.
 - (2) Grasp the hub of the VAD and gently and steadily retract catheter until completely removed.
 - i) Send catheter tip for culture with provider order if the VAD removal indicates infection.
 - j) Apply constant firm pressure to exit site until bleeding stops (longer in patients with coagulopathies or patients on anticoagulant therapy). Apply occlusive dressing. Change in 24 hours and assess site. Some institutions use triple-antibiotic gauze or petroleum jelly gauze when dressing is applied to prevent air from entering SC space.
 - k) Instruct patient or caregiver to report any discomfort or signs of bleeding, bruising, erythema, edema, and drainage.
 - l) Inspect device for appropriate length and for defects. Report any defects to the manufacturer and regulatory agencies. Examine

- distal tip for signs of jagged, uneven edges suggestive of breakage.
- m) Document observations, patient tolerance, and actions.
 - n) Contact a physician immediately if difficulty occurs in retrieving the cuff or with removal of catheter.
 - o) If tunnel infection is suspected, a cut-down procedure may be performed to remove the cuff, based on physician preference.
 - p) If there is a question of incomplete catheter removal, call the physician immediately. A chest x-ray or cathetergram is recommended.
6. Maintenance and care (see Tables 1 and 2)
- a) Dwell time: Several years
 - b) Dressing: Dressing changed 24 hours after insertion.
 - (1) Transparent dressing changed every five to seven days. Gauze and tape dressing changed every two days or as needed if wet, soiled, or nonocclusive.
 - (2) Once healed, tunneled catheters may go without a dressing unless the patient is immunocompromised (Olson et al., 2004).
- (3) Instruct patients with external catheters who shower or swim to completely cover exit site and external catheter with a waterproof covering (e.g., AquaGuard[®], Cenorin, LLC). Some physicians prefer that patients with external catheters refrain from swimming because water can contain virulent organisms. Little information is available in the literature on swimming with external catheters and the increased risk of infection.
 - c) Flushing: Heparin 10–100 IU/ml: 3 ml/day or 3 ml/day every other day or 5 ml three times a week or 5 ml weekly. Groshong: 5–10 ml normal saline every week.
 - d) Cap change: Every week or month depending upon use
 - e) For blood specimens: Discard 3–5 ml of blood, obtain specimen, and flush with 10–20 ml of normal saline.
7. Complications: See Section II.I and Tables 5 and 6 (Green, 2008; Hamilton, 2006).
8. Education and documentation: See Section X.
9. For a practicum on long-term venous device care, see Appendix 4.

Table 5. Venous Access Device Insertion Complications

Complication	Etiology	Symptoms	Clinical Intervention
Air embolism (Lyons et al., 2008; Mirski et al., 2007)	Occurs when intrathoracic pressure becomes less than atmospheric pressure at the open needle or catheter	Sudden respiratory difficulty, tachypnea; cyanosis; chest pain; apnea; hypotension; cardiac arrest; aphasia; seizures; hemiplegia; coma; a churning sound heard over the pericardium on auscultation, produced by the presence of air and blood in the right ventricle	Clamp catheter proximal to any breaks or leaks noted; place patient on left side in Trendelenburg position; administer 100% oxygen; attempt to aspirate air from vascular access device.
Brachial plexus injury (Karakaya et al., 2000; Porzionato et al., 2003)	Occurs when advancing catheter into jugular vein. This process can also injure the phrenic and laryngeal nerves.	Tingling of fingers, pain shooting down arm, paralysis	Observe symptoms, which usually resolve in minutes to several hours after insertion; administer analgesics as necessary. If symptoms persist, remove vascular access device.
Carotid artery puncture	Occurs when artery is punctured during percutaneous internal jugular vein catheterization	Rapid hematoma formation; internal or external bleeding at insertion site; pallor; weak pulse; tachycardia; stroke; hypotension; upper airway impingement if trachea is compressed	Remove needle or catheter; apply local pressure; perform chest x-ray; observe site and patient closely for several hours.
Cardiac tamponade (Ahmed et al., 2009; Askegard-Giesmann et al., 2009)	Results from cardiac compression of fluid accumulated within the pericardial sac, exerting increased pressure around the heart that restricts blood flow in and out of the ventricles. Occurs when catheter causes cardiac perforation.	May occur hours or days after insertion; anxiety; tachypnea; mild dyspnea to severe respiratory distress; light-headedness; restlessness; confusion; chest discomfort (fullness, heaviness); cyanosis; face and neck vein distention; decreased heart sounds; hypotension; tachycardia	Remove catheter and perform pericardial aspiration. May require surgery to perform pericardial window and placement of drainage tubes.

(Continued on next page)

Table 5. Venous Access Device Insertion Complications (Continued)

Complication	Etiology	Symptoms	Clinical Intervention
Catheter embolism (de Graff et al., 2006; Mirza et al., 2004; Surov et al., 2008)	May occur when catheter is pulled back and sheared off through inserting needle; catheter rupture; or pinch-off syndrome	Chest pain, cardiac arrhythmias	If in the periphery, apply tourniquet, ensuring not to occlude arterial pressure; obtain stat radiology consult to determine strategy for fragment removal.
Catheter tip malposition (Trerotola et al., 2007)	Occurs when catheter tip is misdirected on insertion. Malposition of catheter can cause cardiac perforation, tamponade, venous thrombosis, or cardiac arrhythmias (especially ventricular). Inadvertent catheter placement into other veins (e.g., azygos, brachiocephalic, jugular)	Withdrawal occlusion; sluggish infusion; patient reports tingling sensation and gurgling sounds in neck; arm/shoulder pain; chest pain; cardiac arrhythmias; cardiac arrest	Confirm placement; reposition catheter using fluoroscopy or guidewire exchange; remove catheter.
Exit-site bleeding/hematoma	Caused by introducer sheath larger than catheter left in place or traumatic insertion. Patient may have coagulopathies or thrombocytopenia or be on anticoagulants.	Oozing or frank bleeding from the exit site sometimes persisting for several hours; discoloration or bruising; may result in compartment syndrome (large pooling of blood) in extreme cases (i.e., in the antecubital fossa, a triangular space exists where blood can accumulate, forming a compartment) (Udy et al., 2009)	Apply local pressure; change dressing as needed; drain compartment; observe area frequently; remove catheter if necessary. Apply Gelfoam® (Pfizer Inc.) or fibrin to stop or decrease bleeding.
Pneumothorax, hemothorax, chylothorax, or hydrothorax (McGee & Gould, 2003; Vahid, 2006)	Caused by air, blood, lymph, or infusion fluid in the pleural cavity due to pleura, vein, or thoracic duct injury during catheter insertion	Chest pain; tachypnea; dyspnea; decreased breath sounds; shift in location of heart sounds; cyanosis; decreased cardiac output	Perform chest x-ray and discontinue infusions; administer oxygen; prepare for needle aspirations and chest tube drainage. Perform thoracotomy for repair if necessary.
Subclavian artery damage	Occurs when advancing needle is directed laterally to the subclavian vein and the subclavian artery is penetrated; can result in arterial embolism	Rapid hematoma formation; internal or external bleeding at insertion site; pallor; weak pulse; tachycardia; hypotension; upper airway impingement if trachea is compressed	Remove needle/catheter; apply local pressure; perform chest x-ray; and observe patient and site closely for several hours.

Table 6. Treatment of Device Occlusions

Occlusion	Treatment Protocol*
Blood/fibrin	Instill tPA 2 mg/2 ml sterile water, wait 30–120 minutes, and aspirate. Repeat if unsuccessful. Remove device if unable to resolve occlusion.
Mineral precipitate	Instill hydrochloric acid 1 ml of 0.1 N equal to internal volume of vascular access device (VAD), wait 20 minutes, and aspirate. Repeat if unsuccessful. Remove device if unable to resolve occlusion.
Medication precipitate	Instill sodium bicarbonate of 8.4% solution (1 mEq/ml) equal to internal volume of VAD. Wait 20 minutes. Aspirate and repeat if unsuccessful. Remove device if unable to resolve occlusion.
Lipids	Instill 70% ethanol (ethyl alcohol) equal to internal volume of VAD. Wait one to two hours. Repeat if necessary. Remove device if unable to resolve occlusion. Infuse sodium hydroxide (soda lye, NaOH) 0.1 N 10 ml at 1 ml/hr, then quick flush with 20 ml 0.9% sodium chloride. Repeat if necessary. Remove device if unable to resolve occlusion.
Venous thrombosis	Administer anticoagulation therapy with heparin, low-molecular-weight heparin, or infusion of fibrinolytic agent.

* Use a syringe 3 ml or larger to instill medication.

mEq—millequivalent; tPA—tissue plasminogen activator

Note. Based on information from Bader et al., 2006; Cummings-Winfield et al., 2008; Kerner et al., 2006; Liu et al., 2004.

G. Implanted venous ports (see Figure 6)

1. Description and types (Gallieni et al., 2008; Vescia et al., 2008)

a) All ports are designed with a portal body and a catheter.

(1) The portal body consists of a septum and reservoir within the portal housing.

(a) The portal body is made of plastic, titanium, polysulfone, or a combination of materials.

(b) The portal body has two to eight suture holes to stabilize the port in the port pocket.

(c) Portal bodies are available in standard height and low profile for smaller chests and/or peripheral placement, measuring from 9.8–17 mm.

(d) The weight of the portal body ranges from 4.8–34 g.

(e) The diameter of the portal body ranges from 16.5–40 mm.

(f) Port systems (“power ports”) have been introduced to allow for power injection of contrast material. Using at least a 10 ml syringe, the port can withstand infusions at a rate of up to 5 ml/s at a maximum of 300 psi (Bard Access Systems, 2007b; Navilyst Medical, Inc., n.d.). Maximum pressure for non-power ports is 40 psi.

(g) The Vortex Port® system (AngioDynamics, 2009) employs a rounded inner portal body and place-

ment of the catheter on the portal body to encourage a circular flow of fluid through the portal body. The chaotic flow through the portal body potentially decreases out-flow obstruction and infections by minimizing the collection of blood and other matter in the portal body (Goossens et al., 2008; Stevens et al., 2000).

(2) The septum is made of densely compressed silicone.

(a) Each septum can withstand 1,000–3,600 punctures, depending on the device and the size of the noncoring needle used (Hayden & Goodman, 2005).

(b) The septum of a peripheral port can withstand up to 500 punctures with a 22-gauge needle (Smiths Medical, 2005a).

(3) Inside the portal body is a reservoir with a volume of 0.2–1.47 ml.

b) The catheter is available preattached to the portal body or separate from the portal body. The catheter is attached at the time of insertion with a locking device.

(1) Catheters range in length from 19.7–35.4 inches and in sizes from 4–12 Fr. Catheters are available with an open end, a valve distal end, or PASV (Navilyst Medical, n.d.). PASV technology also is located at the portal body and catheter connection in open-ended catheter ports.

(2) Various locking devices are available to connect the unattached catheters to the portal body during insertion, including locking collars, bayonet locks, and locking sleeves.

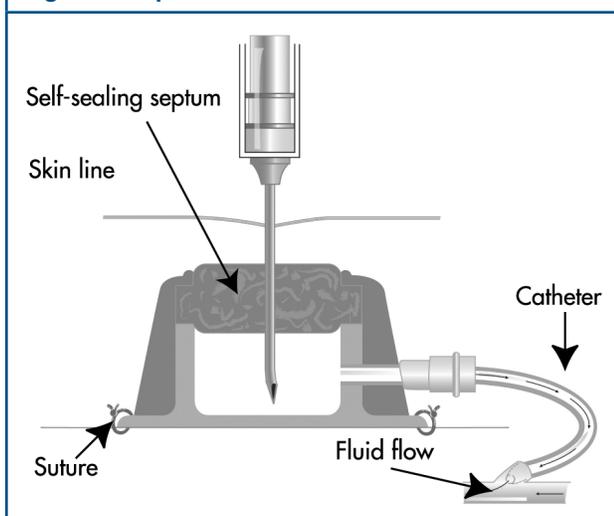
(3) A needle guard is present on the catheter and portal body connection to protect the catheter from accidental needle puncture when the port is accessed.

(4) Ports are available in single- and double-lumen designs with catheters made of silicone or polyurethane.

c) Radiopaque

(1) Many portal bodies have some component of radiopacity to confirm catheter locking mechanism is intact, and the catheter itself is often radiopaque to confirm tip placement. However, ports often are designed to cause minimal interference with diagnostic testing.

Figure 6. Implantable Port



- (2) Some portal bodies have radiopaque identifiers that when imaged can confirm the presence of a flipped portal body.
 - (3) Certain radiologic technologies may need to be implemented to assist with interpretation, such as the use of contrast medium.
 - d)* A peripheral port also is available for placement proximal or distal to the antecubital fossa. The portal body is approximately half the size of a standard port with a longer catheter (open-ended, valve-ended, or PASV). Peripheral ports are only available as single lumens.
 - e)* Cost of implanted port includes insertion kits, the device, use of operating room or interventional radiology suite, placement verification (chest x-ray or fluoroscopy), and maintenance supplies for therapy at home.
 - f)* Insertion expenses generally are covered by health insurance. Patients should check with their insurance representative or case manager about reimbursement issues.
2. Advantages and disadvantages (see Table 4)
3. Patient selection criteria
- a)* Patients who require intermittent IV therapy
 - b)* Patients who are unwilling to care for an external line
 - c)* Patients who are unable to care for an external line because of poor vision, poor dexterity, inability to comprehend, or lack of caregiver
 - d)* Patients with a very active lifestyle, including swimming and outdoor activities
 - e)* Peripherally placed ports are an option in patients with chest pathology or those patients in whom obesity would make it difficult to access a chest-placed port.
 - f)* Adequate antecubital veins are necessary for peripheral port placement.

- g)* Patients with poor peripheral access and ongoing IV needs
 - h)* Poor candidates for port placement:
 - (1) Patients who are extremely obese, because the port must be sutured to the muscle and under the adipose layer, making it difficult to locate and access the port septum. Also, the port can migrate further in SC tissue.
 - (2) Patients who find needlesticks extremely traumatic
 - (3) Patients with open chest wounds, tumor involvement of the chest wall, or radiation fibrosis, because ample chest area is required
4. Insertion techniques
- a)* Ideally, the nurse should assist in determining the optimum location for the portal body (Hayden & Goodman, 2005).
 - (1) The portal body should be located over a rib for stability.
 - (2) Placing the port over the sternum in obese patients assists in locating and accessing the port.
 - (3) In women, the port should not lie under a bra strap or edge; therefore, the woman should be sitting and clothed when placement is determined.
 - (4) Consider the activity level of the patient.
 - (5) Avoid placement in the axilla, breast tissue, or soft tissue of the abdomen to avoid access problems.
 - (6) A preferred site and an alternate site should be marked for the surgeon.
 - (7) A peripheral port is placed below or above the antecubital fossa to minimize range of motion impairment.
 - b)* After giving consent, the patient is taken to the operating room or interventional radiology. The procedure may be performed under straight local anesthesia, a local with the addition of sedation, or general anesthesia. Insertion may be performed under fluoroscopy to facilitate correct tip placement.
 - c)* The catheter is placed using the cut-down technique or the percutaneous method.
 - (1) Preattached catheters are measured and cut from the distal end.
 - (2) Separate catheters are inserted and then may be cut at the proximal (portal body) end.
 - d)* If portal body is separate, the catheter is connected per manufacturer's instructions based on the type of locking mechanism.

- e) An incision is made to create a port “pocket,” preferably in a previously determined location.
- (1) The portal body is placed over a bony area for stabilization, under the adipose layer, and sutured to the fascia layer.
 - (2) The suture line should not be over the top of the port septum to maintain the integrity of the suture line (Hayden & Goodman, 2005).
- f) Following closure of the port pocket, the port is accessed using a noncoring needle, and the system is flushed to ensure patency and blood return.
- (1) If the port is to be used immediately, the needle should be left in place and dressed occlusively, as postoperative edema and tenderness of the incision make postsurgical access more difficult (Ozdemir et al., 2009).
 - (2) If the port is not used immediately, the needle is removed and a dressing applied over the port pocket incision and the catheter entry site.
 - (3) Ideally, the port should not be accessed for several days to allow edema and tenderness to resolve. If it needs to be used sooner, instruct the patient to apply an ice pack to minimize edema. If the port is used immediately, the patient may not be able to report pain or burning for several hours related to the type of local anesthetic used. Take care and ensure a blood return if administering a vesicant, hyperosmolar agent, or solution with pH less than 5 or greater than 9.
 - (4) When a peripheral port is placed, that arm should not be used to obtain blood pressure and should not be used for peripheral blood drawing or infusions of IV solutions except through the port (Smiths Medical, 2005a).
- g) Radiographic imaging is obtained following insertion to determine tip placement in the distal third of the superior vena cava and to assess for complications of insertion.
5. Access and deaccess procedures (see Appendix 5 and Figure 7)
- a) Implanted ports must be accessed with a special noncoring needle (see Figure 6).
 - (1) A specially designed needle tip separates the silicone septum, preventing “coring” of the diaphragm, which could lead to debris in the reservoir and ultimate degradation of the integrity of the septum.
 - (2) An offset bevel allows the tip of the needle to be flush with the bottom of the reservoir without impeding the flow of solution.
 - (3) Noncoring needles are available in a variety of sizes and configurations.
 - (a) Length varies from 0.5–2 inches.
 - (b) Most commonly used gauge is 19–22.
 - (c) Straight needles are available for flushing with immediate deaccessing or bent at a 90° angle for intermittent or continuous infusions.
 - (d) Needles are available with various types of short pieces of extension tubing attached with and without clamps.
 - i. Wings may or may not be attached to the hub for easier access and stabilization of the needle to the chest.
 - ii. The extension tubing may have a Y-site.
 - (e) Power needles are available for power ports.
 - (f) Huber needles are available with a built-in safety system to prevent

Figure 7. Port Access



Note. Photo courtesy of Hematology Oncology Associates of Alabama, LLC. Used with permission.

- accidental needlestick. When the needle is removed from portal system, the needle is covered with a safety mechanism (SafeStep[®], C.R. Bard, Inc.).
- b) To decrease discomfort during needle access, the patient may be offered topical anesthetic with a physician's order (see Table 3).
 - c) Port access procedure
 - (1) Wash hands. Prior to each access, the site should be examined for complications, including examination of the veins of the ipsilateral chest and neck, which might reveal venous thrombosis, erythema, drainage, or leakage.
 - (2) Palpate the outline of the portal body.
 - (3) Wash hands. Apply gloves. Cleanse port site with chlorhexidine for 30 seconds and allow to dry.
 - (4) Administer topical anesthetic, if ordered. Stabilize portal body with one hand. Insert Huber needle into septum with the other hand until portal backing felt.
 - (5) Ensure patency by blood return. If no blood return, use interventions to assess port patency.
 - (6) Stabilize port with tape, securement device, or stabilization device. Apply dressing. For short-term use, such as for outpatient treatment, gauze and tape could be used after stabilizing needle.
 - d) Port deaccess procedure
 - (1) Wash hands and apply gloves.
 - (2) Remove dressing and inspect site. Remove gloves.
 - (3) Wash hands. Apply gloves. Flush device with 20 ml normal saline followed by heparin flush.
 - (4) Stabilize port with one hand, and remove needle with the other hand. Maintain positive pressure while deaccessing by flushing the catheter while withdrawing the needle from the septum.
 - (5) Apply bandage or dressing.
 - e) When not in use, implanted ports must be accessed and flushed every four to eight weeks to maintain patency. However, no evidence exists to support the optimal frequency for maintenance flushing (Gholz, Whitehill, & Franer, 2009; Kefeli et al., 2009; Kuo et al., 2005).
6. Port removal technique
 - a) Procedure can be performed in the operating room or in an outpatient setting.
 - b) A cut-down procedure is used to remove the port from the port pocket.
 - c) The catheter is removed by pulling outward. The port pocket incision is reclosed with sutures or Steri-Strips.
 7. Maintenance and care (see Table 1) (Camp-Sorrell, 2007; CDC, 2002; Gillies et al., 2003; INS, 2006; Lyons et al., 2008)
 - a) Dressing materials used during continuous port infusions
 - (1) Gauze and tape: Changed every 48 hours or when wet, soiled, or no longer occlusive
 - (2) Transparent dressing: Changed every five to seven days or more often, as indicated
 - (3) An occlusive dressing should be changed along with the needle once weekly, unless soiled, wet, or no longer intact.
 - (4) An occlusive dressing should be applied to any port site when the needle is to be left in; however, for short-term infusions, a light dressing may be used in place of an occlusive dressing if desired. More research is needed to determine the type of dressing needed for short-term infusions. The important aspect is to ensure the needle is secure in the portal septum with tape, Steri-Strips, and a securement or stabilization device. If the needle does not lie securely to the skin, padding (such as gauze) is needed to fully secure the needle into the septum.
 - b) Flush each port lumen (i.e., double-lumen ports). Flushing technique: Every four to eight weeks with 5 ml heparin solution (100 IU/ml) when not in use. Flush with 10–20 ml after infusing medications or withdrawing blood (Gholz et al., 2009; Kefeli et al., 2009; Kuo et al., 2005).
 - c) Blood withdrawal: Remove and discard 5–10 ml of blood. Draw specimen. Flush with 10–20 ml of normal saline.
 - d) Change port needles every week per manufacturer. Frequency to replace is an unresolved issue (CDC, in press).
 8. Complications: See Section II.I and Tables 5 and 6.
 9. Education and documentation: See Section X.
 10. For a practicum on implanted port care, see Appendix 5.

H. Apheresis/hemodialysis catheters

1. Description and types (Otto, 2005)

a) Temporary nontunneled catheters constructed of silicone or polyurethane material, or a combination of both, provide access for apheresis or hemodialysis.

- (1) Open-ended catheter requires clamping during IV access for connection of IV tubing or syringes.
- (2) Catheter length ranges from 12–40 cm, with an outer diameter ranging from 10–18.5 Fr and an internal diameter ranging from 1.5–2 mm.
- (3) Available in single- and double-lumen designs.
- (4) Priming volume of catheter is 0.8–1.5 ml, allowing a flow rate of 300–400 ml/hr or greater.

b) Tunneled catheters constructed from silicone provide long-term access for apheresis or hemodialysis (Bard Access Systems, 2007a).

- (1) Open-ended catheter requires clamping during IV access for connection of IV tubing or syringes.
- (2) Available with Dacron or antimicrobial cuff.
- (3) Ointments containing polyethylene glycol (PEG) should not be placed on these catheters. PEG causes the polyurethane catheter material to become opaque, swell, and crack. PEG is a common ingredient in many antimicrobial ointments.
- (4) Catheters range from 8.4–11.5 Fr in lengths of 5.4–18 inches.
- (5) Available in single-, double-, and triple-lumen designs. The third lumen of the triple-lumen design is a smaller lumen.

2. Advantages and disadvantages: See Table 4.

3. Patient selection criteria are based on type of therapy or indications for use.

a) Patients who require apheresis of blood components, including stem cells, to be used with HSCT. A temporary catheter may be used for collection of stem cells from allogeneic donors who have poor peripheral venous access.

b) Patients who require leukapheresis

c) Patients who require plasmapheresis

d) Patients who require hemodialysis for management of acute and chronic renal failure

e) Patients who may need venous access for continuous arterial venous hemodialysis,

ultrafiltration, or continuous veno-venous hemodialysis

4. Insertion techniques: See Section II.D for nontunneled catheters or Section II.F for tunneled catheters.

5. Removal techniques: See Section II.D for nontunneled catheters or Section II.F for tunneled catheters.

6. Maintenance and care (see Section II.D and Tables 1 and 2)

a) Dwell time: Several years for tunneled, and short-term for nontunneled (approximately seven days)

b) Dressing: Dressing changed 24 hours after insertion.

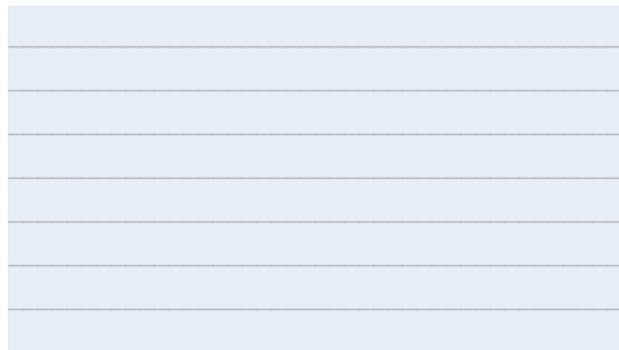
(1) Transparent dressing changed every five to seven days. Gauze and tape dressing changed every two days or as needed if wet, soiled, or nonocclusive.

(2) Once site is healed, tunneled catheters may go without a dressing unless patient is immunocompromised.

(3) Instruct patients with external catheters who shower or swim to completely cover exit site and external catheter with waterproof covering (e.g., Aqua-Guard). Some physicians prefer that patients with external catheters refrain from swimming because water can contain virulent organisms. Little information is available in the literature on swimming with external catheters and the increased risk of infection.

c) Flushing

(1) If frequent use of the catheter is indicated, change the heparin flush concentration to 1,000 IU/ml and flush every day or after use. If the heparinized saline is not aspirated and discarded, monitor coagulation levels (i.e., partial thromboplastin time) because this amount of heparin may lead to therapeutic serum levels.



- (2) Some institutions require a physician order if the catheter is to be used for reasons other than hemodialysis or apheresis.
 - (3) Typical flush includes heparin 1,000–5,000 IU/ml after each treatment; 1–2 ml/day.
 - (4) Hemodialysis/apheresis catheters should be flushed after use for hemodialysis or apheresis.
- d) Cap change: Every week depending on use or if cap is not intact
 - e) Blood specimens: Discard 5 ml of blood, obtain specimen, and flush with 10–20 ml of normal saline after blood withdrawal.
7. Complications: See Section II.I and Tables 5 and 6.
 8. Education and documentation: See Section X.
- I. Complications of short- and long-term VADs
1. Prevention of complications (CDC, in press; IHI, n.d.)
 - a) Central venous catheterization should be performed only when the potential benefits appear to outweigh the inherent risks of the procedure.
 - b) Catheter tip should *not* be placed in or allowed to migrate into the heart. The distal tip of a CVC (other than short-term peripheral catheters and subclavian catheters) should be placed in the superior vena cava at the junction of the right atrium. Placement too high in superior vena cava increases the risk for thrombus or migration of catheter tip. Tip too low in right atrium can trigger dysrhythmias (Bishop et al., 2007; Gallieni et al., 2008).
 - c) Catheter tip position should be confirmed using x-ray or another imaging modality, such as cathetergram or ultrasound, and be rechecked if symptoms of malposition or no blood return is present. Some clinicians have suggested that catheter placement be checked by chest x-ray every three months (Aitken & Minton, 1984; Gallieni et al., 2008; Kerner, Garcia-Careaga, Fisher, & Poole, 2006).
 - d) Central venous catheterization must be performed by trained personnel who are knowledgeable in anatomic landmarks, safety techniques, sterile barrier precautions, and potential complications. Users in training must be supervised closely by qualified personnel to ensure their technical expertise before independent perfor-
 - mance of these procedures. Ongoing monitoring of experienced trainees should be undertaken to ensure continued competence.
 - e) Those placing VADs should be familiar with the specific equipment used as well as with the proper selection of insertion site, vein site, and catheter type, size, and length. Except in emergencies, catheterization should be performed with full aseptic technique, which includes hand washing, sterile gloves, mask, hat, gown, drapes, and proper skin antiseptic (Pratt et al., 2007).
 - f) Those caring for patients with indwelling VADs should be well informed of the appropriate care and associated complications of VADs.
 - g) Manufacturers should include specific labeling to address the potential complications of VAD use. Therefore, users should read all manufacturer labels, instructions, and warnings because they contain important and useful information for the safe and effective use of the catheter.
 - h) Catheters placed in less-than-sterile fashion should be replaced as soon as medically permissible.
2. Insertion complications (Gallieni et al., 2008): See Table 5.
 3. Postinsertion complications/interventions
 - a) Catheter migration (DeChicco et al., 2007)
 - (1) Etiology: Catheter tip migrates spontaneously from the superior vena cava because of a change in intrathoracic pressure related to coughing, sneezing, or vomiting; forceful flushing; vigorous upper extremity movements; or accidentally by patient or caregiver pulling on catheter (DeChicco et al., 2007; Pikwer, Baath, Davidson, Perstoft, & Akesson, 2008).
 - (2) Symptoms: May include change in ability to infuse fluids or withdraw blood; increased external catheter length; and patient report of tingling sensation or gurgling in neck, arm or shoulder pain, vague back discomfort, swelling, chest pain, or arrhythmia.
 - (3) Diagnostic tests such as x-ray or cathetergram if catheter tip malposition is suspected
 - (4) Clinical interventions to reposition catheter tip or flipped port (Guth, 2001;

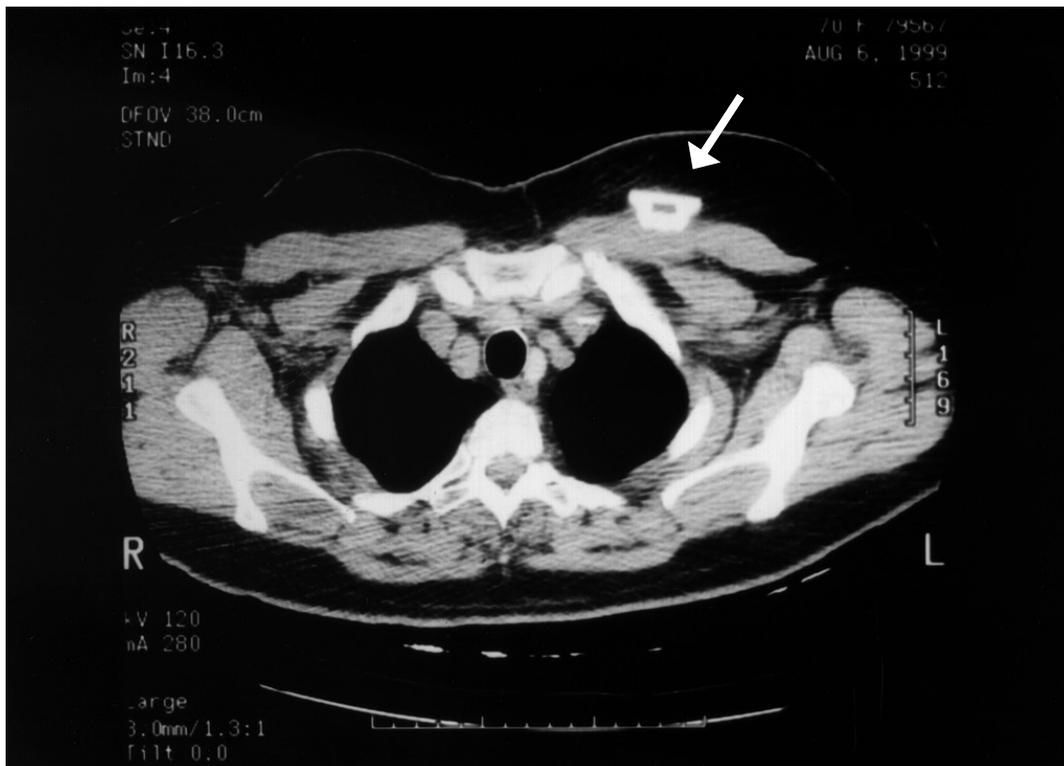
Thalhammer, Jacobi, Balzer, & Vogl, 2002)

- (a) Use patient positioning to redirect catheter.
 - (b) Employ fluoroscopic catheter guidance to redirect catheter.
 - (c) Nontunneled VADs: Perform partial catheter withdrawal or guide-wire catheter exchange. The potential exists for complications, such as shearing the catheter or reintroducing infectious organisms.
 - (d) Power flushing for PICCs
 - (e) Remove catheter.
 - (f) Surgically reposition port in pocket.
- (5) Ports can flip in the SC tissue and need to be surgically corrected (see Figure 8).
- b) Pinch-off syndrome (D'Silva, Dwivedi, Shetty, & Ashare, 2005; Jensen, 2008; Mirza, Vanek, & Kupensky, 2004; Nuss, Cole, Le, Orsini, & Harned, 2008; Surov et al., 2008)
- (1) Definition: The anatomic, mechanical compression of a catheter as it pass-

es between the clavicle and first rib at the costoclavicular space

- (2) Etiology: When percutaneously placed too medially, the catheter travels through the costoclavicular space next to the subclavian vein rather than inside it, therefore becoming vulnerable to compression with shoulder movement. Catheter fracture is defined as the complete or partial breakage of a VAD catheter internally with migration of the distal catheter fragment, usually into the right ventricle or pulmonary artery.
- (3) Symptoms of pinch-off: Difficulty infusing fluids or withdrawing blood, able to infuse or withdraw with patient repositioned such as raising arms or changes in shoulder position, lying supine
- (4) Symptoms of fracture: Arrhythmia, extra heart sound, palpitations, extravasation, shortness of breath, unable to draw blood
- (5) Diagnostic tests

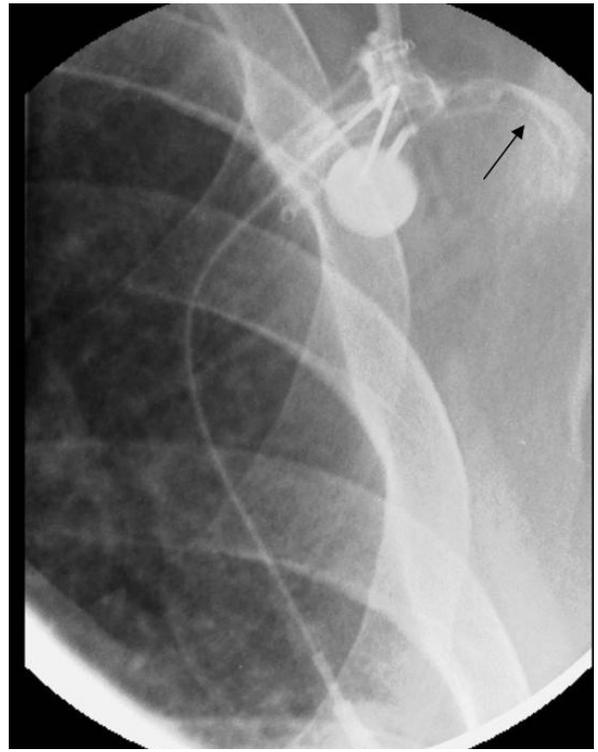
Figure 8. Rotation of Port



Note. From "Unusual Port Presentation," by D. Camp-Sorrell, 2001, *Clinical Journal of Oncology Nursing*, 5, p. 115. Copyright 2001 by Oncology Nursing Society. Reprinted with permission.

- (a) Early radiographic (chest x-ray) detection of catheter compression is vital to prevent catheter fracture. For accurate imaging, patient should be upright with arms at side.
- (b) If there is radiographic confirmation of pinch-off with luminal narrowing, the catheter should be removed and reinserted appropriately (Kerner et al., 2006; Mirza et al., 2004).
- (6) Prevention
 - (a) To prevent pinch-off syndrome, the catheter should be inserted laterally to the midclavicular line. This places the catheter inside the subclavian vein, instead of next to the vein, through the clavicle and first rib.
 - (b) Pinch-off syndrome can be assessed intraoperatively following insertion of a long-term VAD by fluoroscopically evaluating the catheter during movement of the ipsilateral shoulder to evaluate narrowing of the catheter lumen (Mirza et al., 2004).
 - (c) Heavy lifting should be minimized if pinch-off has been identified. Case reports exist of fractures occurring within weeks of lifting weights.
 - (d) If fracture occurs (see Figure 9), embolized fragment removal should be attempted in interventional radiology (Mirza et al., 2004).
- (7) Monitoring for pinch-off syndrome
 - (a) Surveillance x-rays should be used immediately following insertion of a catheter and at regular intervals in the first six months following insertion (such as months 1, 3, and 5) (Mirza et al., 2004). No studies confirm frequency of surveillance or the type of imaging study to be performed.
 - (b) If pinch-off syndrome is suspected or confirmed, the catheter should be removed immediately because of the high risk of catheter embolization.
- c) Occlusions (partial/total): See Table 6.
 - (1) Etiology (Bader, Balke, Jonkers-Schuitema, Tas, & Sauerwein, 2006; Camp-Sorrell, 2007; Couban et al., 2005;

Figure 9. Port Fracture With Leakage (Arrow) of Dye



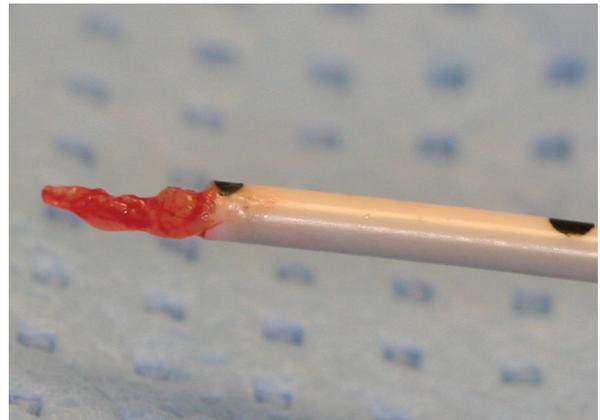
Note. Image courtesy of the Carole and Ray Neag Comprehensive Cancer Center, University of Connecticut Health Center. Used with permission.

Hadaway, 2006; Kerner et al., 2006; Lyons et al., 2008; Shah & Shah, 2007)

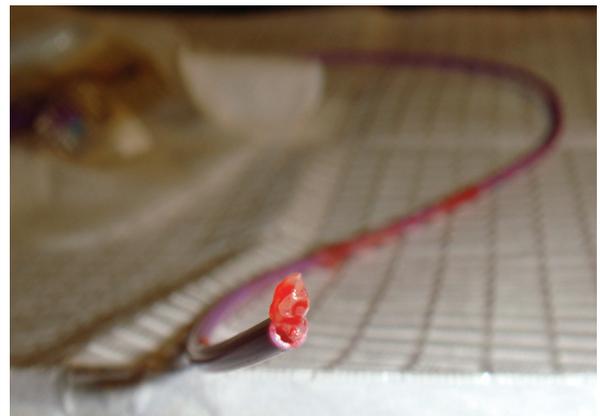
- (a) Intraluminal blood/fibrin forms within the catheter lumen, resulting in partial or complete occlusion.
- (b) Precipitates or lipid deposits occur from infusion of incompatible solutions or inadequate flushing resulting in drug crystallization.
- (c) Fibrin tail or sheath (see Figure 10) occurs when fibrin adheres to the tip of the catheter and external surface, acting as a one-way valve permitting infusion but not withdrawal of blood.
- (d) Mural thrombosis occurs when the fibrin from the catheter surface binds with fibrin from a vessel wall injury and forms a venous thrombus.
- (e) Occlusions also can result from the port needle not being in the proper position.

- (2) Risk factors: Normal physiologic clotting response, type of malignancy (such as solid tumor of the lung), thrombogenic composition of VAD, location of catheter tip (increased risk of thrombosis if catheter tip is located proximal to lower third of superior vena cava) (Blom, Doggen, Osanto, & Rosendaal, 2005; Couban et al., 2005; Kuter, 2004; Lyons et al., 2008); infusion of incompatible solutions, drug crystallization, and inadequate routine flushing (Hadaway, 2006; Kerner et al., 2006).
- (3) Prevention
- (a) Adequate catheter flushes with normal saline and locking with low-dose heparin solution both routinely and after catheter use can aid in preventing occlusions.
 - (b) Systemic anticoagulation remains a controversial method of minimizing catheter occlusions because of the risk of complications. Oral low-dose warfarin (1 mg/day) has been shown to decrease the rate of catheter-related thrombosis but may increase the patient's risk of bleeding (Akl et al., 2008; Couban et al., 2005; Kuter, 2004; Young et al., 2009). Currently, routine use of systemic anticoagulation is not recommended (Geerts et al., 2008; Pratt et al., 2007).
 - (c) Routine locking with thrombolytics such as high-dose heparin and tissue plasminogen activator (tPA) requires more research (McGill, Spero, Sysak, Sandroni, & Marcus, 2008; Moran & Ash, 2008; Ragni, Journeycake, & Brambilla, 2008).
 - i. Alteplase (recombinant tPA, Cathflo® Activase®, Genentech, Inc.) has been proved safe and effective for the prevention of fibrin buildup that may lead to catheter dysfunction. tPA degrades fibrin clots as well as fibrinogen and other plasma proteins by activating plasminogen to the active enzyme plasmin (Bamgbola, del Rio, Kaskel, & Flynn, 2005; Blaney et al., 2006; Davies, Casey, Li, Crowe, & McClelland, 2004; Fisher, Deffenbaugh, Poole, Garcia, & Kerner, 2004). tPA currently is the

Figure 10. Catheter With Fibrin Tail



Fibrin tail with "initial" attachment on the outside of catheter, allowing for "trap door" effect and demonstration of partial withdraw occlusion; ability to flush easily but no blood return when attempting to aspirate.



Fibrin tail with attachment on the inner aspect of catheter; however, this is a triple-lumen catheter, and it demonstrates that close proximity of lumens can be occluded with single fibrin buildup.



Fibrin tail and the extent of "clot burden" extend approximately 4 cm inside the catheter.

Note. Photos copyright by Penny Offer, CRNI. Used with permission.

most commonly used agent to treat catheter occlusion.

- ii. Reteplase and tenecteplase, recombinant forms of tPA, currently are available only for treatment of myocardial infarction. With more research, these agents may be alternative treatments for catheter clearance (Liu, Jain, Shields, & Heilbrun, 2004).
 - iii. Urokinase is an enzyme produced by the kidneys and found in the urine that converts plasminogen to plasmin. This action degrades fibrin clots as well as fibrinogen and other plasma proteins. Maintenance use has been shown to decrease the rate of occlusion from fibrin buildup (Molinari et al., 2004; Svoboda et al., 2004). Urokinase currently is being marketed in large vials only and is indicated for pulmonary emboli.
- (4) Symptoms (Camp-Sorrell, 2007; Kerner et al., 2006)
- (a) Partial: Inability to withdraw blood but able to infuse; difficulty withdrawing blood and infusing fluids; ability to infuse or withdraw dependent on patient position
 - (b) Total: Inability to withdraw blood or infuse fluid
 - (c) Venous thrombosis: Pain or edema in neck or upper extremities
 - (d) Edema distal to insertion site (possible with PICCs and superior vena cava syndrome)
- (5) Diagnosis of occlusion
- (a) Diagnosis of thrombin complications may be based on symptoms.

- (b) Diagnosis of lipid deposits or precipitates may be based on drug regimen.
 - (c) Cathetergram or dye study can be used to image the tip of the catheter and to assess for backtracking of fluids.
 - (d) Doppler ultrasound may be used to diagnose venous thrombosis. Use with catheters with total occlusion.
 - (e) Chest x-ray visualizes the catheter and tip to assess for migration or pinch-off syndrome.
- (6) Clinical interventions: Intraluminal blood or fibrin, precipitates, and lipid deposits; see Table 6 for treatment (Bader et al., 2006; Cummings-Winfield & Mushani-Kanji, 2008; Kerner et al., 2006). Use 3 ml or larger syringe to instill medication. Nonpharmacologic methods include the following.
- (a) Flush the catheter with normal saline gently using the push-pull method.
 - (b) Reposition the patient.
 - (c) Ask the patient to cough and deep breathe.
 - (d) Perform fibrin sheath removal with a snaring or stripping procedure to remove fibrin sheath from catheter tip in interventional radiology (Reddy, Lang, Cutts, Loh, & Rosen, 2007).
- (7) Additional references related to catheter occlusion include Bowers, Speroni, Jones, and Atherton, 2008; Linenberger, 2006; Rosenthal, 2002; Rosovsky and Kuter, 2005; Smith, 2008; and Thibodeau, Riley, and Rouse, 2007.
- d) Infection: VAD-related infections are costly and potentially life threatening; however, the definition, pathogenesis, diagnosis, and treatment of VAD-related infections lack standardization.
- (1) Definitions most commonly used (Bishop et al., 2007; Camp-Sorrell, 2007; CDC, in press; Mermel et al., 2009; Pratt et al., 2007; Moran & Camp-Sorrell, 2002; Tilton, 2006; Vesica et al., 2008; Worthington & Elliott, 2005)
- (a) Local VAD infection: Infection occurs at insertion site, port SC pocket (of a totally implanted intravas-

cular device), or tunnel (along the SC track of the catheter).

- (b) Systemic VAD infection: Most serious type of infection; catheter-related septicemia, semiquantitative or quantitative catheter culture, and blood cultures are positive for the same species with a negative infusate culture; no evidence of another source for the septicemia is disclosed by clinical or microbiologic data.
- (2) Etiology
- (a) Contamination during VAD insertion; colonization of skin at VAD insertion site, exit site, port pocket, or tunnel (CDC, in press; Esteve et al., 2007; Tilton, 2006; Vesica et al., 2008; Worthington & Elliott, 2005)
- (b) Patient neutropenic when VAD was inserted
- (c) Contamination of infusate or any other infusion system components
- (d) Hematogenous seeding of microorganisms from an infection in a remote site within the body
- (e) Physical condition of the patient: Increased risk of infection in immunocompromised patients, patients with advanced age, comorbid conditions, severe illness, and prolonged hospitalizations (Maki & Crnich, 2003)
- (f) Catheter hub contamination during manipulation
- (g) Catheter material upon which bacteria adheres to the surface
- (h) Adherence of bacteria to a fibrin sheath and/or thrombosis, producing an “extracellular slime” that protects the organism from antibodies (Aslam, 2008; Safdar & Maki, 2006)
- (i) Inappropriate use of needleless connection systems (Esteve et al., 2007; Hadaway, 2006; Yebenes & Serra-Prat, 2008; Yoshida et al., 2008).
- (j) Use of parenteral nutrition (Opilla, 2008)
- (k) Use of chemotherapeutic agents that may irritate/extravasate resulting in local/cutaneous infection (Chang, Tsai, Huang, & Shih, 2003)
- (l) The most commonly occurring organisms (Camp-Sorrell, 2007; CDC, in press; Opilla, 2008; Vesica et al., 2008; Worthington & Elliott, 2005)
- i. Coagulase-negative staphylococci
 - ii. *Staphylococcus aureus*
 - iii. *Candida* species
 - iv. *Corynebacterium* species
 - v. *Klebsiella* and *Enterobacter* species
- (3) Prevention (Eggimann et al., 2005; IHI, n.d.; INS, 2006; Marschall et al., 2008; Mermel, 2007; Misset et al., 2004; Pratt et al., 2007; Pronovost, 2008)
- (a) Incorporation of central line bundle into maintenance and care
- i. Frequent hand washing before and after all VAD care
 - ii. Maximal barrier precautions upon insertion
 - iii. Chlorhexidine skin antisepsis
 - iv. Optimal catheter site selection
 - v. Daily review of line necessity with prompt removal of unnecessary lines
 - vi. Alcohol hub decontamination before each hub access
- (b) Consistent maintenance procedures using strict aseptic technique
- (c) Routine surveillance for infection rates
- (d) Patient and caregiver education
- (e) Administration of preplacement antibiotic is not effective in preventing catheter-related infection (CDC, in press; Penel & Yazdanpanah, 2008; van de Wetering & van Woensel, 2007).
- (f) Monitor patients with comorbid diseases such as diabetes or chronic obstructive pulmonary disease or those on corticosteroid therapy closely for infection because these conditions can predispose a patient to infection (Conly, 2005).
- (4) Symptoms (see Figure 11)
- (a) Local: Swelling, tenderness, erythema, induration, cellulitis, and drainage with positive culture
- (b) Systemic: Fever, chills, diaphoresis, fatigue, arthralgias, weakness, hypotension, tachycardia, hyperventilation, mental status chang-

Figure 11. Infected Port Line

Note. From "Maintenance of Venous Access Devices in Patients With Neutropenia," by A.B. Moran and D. Camp-Sorrell, 2002, *Clinical Journal of Oncology Nursing*, 6, p. 128. Copyright 2002 by Oncology Nursing Society. Reprinted with permission.

es, abdominal pain, vomiting, and diarrhea

- (5) Diagnosis of infection (Catton et al., 2005; Gallieni et al., 2008; Mermel et al., 2009; Moran & Camp-Sorrell, 2002; Raad et al., 2004; Tanguy, Seguin, Laviolle, Desbordes, & Malledant, 2005; Worthington & Elliott, 2005)
 - (a) Exit-site infection is diagnosed by cultures (swab) obtained from exudate noted at the exit site. Can occur either with or without a synchronous bloodstream infection.
 - (b) Blood cultures taken from the VAD and peripherally are used to diagnose systemic infections.
 - (c) Cultures can be interpreted either paired (positive versus negative), by measuring the time it takes for a culture to become positive, or quantitatively (compares the number of organisms found in each culture); a VAD culture showing more than 100 colony-forming units/ml is considered a positive culture.
 - (d) VAD catheters positive for bacteremia or fungemia and with no other source of infection found are considered positive for VAD infection.
 - (e) Cultures can be obtained from suspected infusate.
 - (f) Definitive diagnosis of catheter-related infection generally is made by identification of infectious or-

ganism from explanted catheter tip culture (Worthington & Elliott, 2005).

- (6) Clinical interventions (Marschall et al., 2008; Raad, Hanna, & Maki, 2007; Vescia et al., 2008)
 - (a) Daily documentation of site assessment with local inspection and light palpation of exit site, tunnel, or port pocket. Immunocompromised patients may not demonstrate symptoms of infection because of a decrease in the number of white blood cells. If infection is suspected in a port, it is recommended not to access it because of the potential to introduce microorganisms into the bloodstream. However, it may be necessary to access a suspicious port to obtain blood cultures upon a physician order (Camp-Sorrell, 2007).
 - (b) Local infection: Culture exit-site drainage. Apply sterile gauze and tape dressings daily, apply warm compresses, and administer PO/IV antibiotics as ordered for 10–14 days. If symptoms do not resolve within 48–72 hours after initiating antibiotics, remove VAD (Kuizon, Gordon, & Dolmatch, 2001). The use of antibacterial ointment remains controversial (CDC, in press; Lok et al., 2003; McGee & Gould, 2003).
 - (c) Systemic infection: Obtain blood cultures from device and from the peripheral circulation; culture infusate, and consider obtaining cultures from port pocket (Mermel et al., 2009).
- (7) If catheter-related bloodstream infection is suspected, it is recommended that two blood cultures be obtained. One culture is drawn from the catheter, and one culture is drawn from a peripheral venipuncture site and labeled accordingly (Krzywda & Edmiston, 2002). Care should be given to use strict aseptic technique, as one contaminant can produce a false-positive result. Developing a consistent protocol or set of guidelines for blood culturing when catheter-related bloodstream infection is suspected can result in rapid isolation and detection of microorganisms, which will en-

sure prompt and appropriate treatment (Penwarden & Montgomery, 2002).

- (a) More research is needed to determine if blood should be discarded prior to withdrawing the blood specimen for the culture. If the infusate or solution within the internal lumen of the catheter is thought to be contaminated, no blood should be discarded.
 - (b) More research is needed on how to prepare the access site prior to obtaining blood for cultures. Chlorhexidine has shown effectiveness as a cleansing agent.
 - (c) Accessing a port that appears to be infected is controversial. It may be necessary to access it to determine the organism within the port system.
- (8) Treatment (Mermel et al., 2009)
- (a) Administer IV antibiotics. For multilumen catheters, rotate the lumens for antibiotic administration to ensure that all of the lumens are treated.
 - (b) Antibiotic lock technique involves instilling 1–2 ml of high-concentration antibiotic solution into the catheter lumen, allowing the antibiotic to dwell for a period of time, and then withdrawing the antibiotic (Mermel et al., 2009; Rijnders, Van Wijngaerden, Vandencastele, Stas, & Peetermans, 2005; Safdar & Maki, 2006; Yahav et al., 2008).
 - (c) Questions still remain, including the appropriate antibiotic concentration, duration of treatment, and instillation time.
 - (d) The use of antibiotic-lock flushes (e.g., vancomycin) remains controversial because of the risk of allergic reaction and formation of resistant organisms (CDC, in press; Safdar & Maki, 2006).
 - (e) If thrombus-related infection is present, consider thrombolytic or anticoagulant therapy concurrently with antibiotics to prevent further clotting and to lyse the existing clot because the residual clot may harbor microorganisms, resulting in recurrent infection.
 - (f) Perform surgical stripping of thrombus from vein if traditional

measures are not effective (Reddy et al., 2007).

- (g) If a nontunneled catheter is involved, a guidewire exchange of catheter is contraindicated because the infection could be reintroduced into the bloodstream (CDC, in press). However, some reports exist of successful management of tunneled catheters by guidewire exchange (Casey et al., 2008).
 - (h) If the patient remains symptomatic 24–48 hours after initiation of antibiotics, remove the VAD.
 - (i) Catheter removal usually is warranted for the following (Bishop et al., 2007; Mermel et al., 2009; Raad et al., 2007; Vescia et al., 2008).
 - i. Persistent or recurrent tunnel infection after antibiotic therapy for three to four weeks
 - ii. Fungus, gram-negative bacilli, enterococcus, or yeast infection
 - iii. Continuation of signs and symptoms of infection despite antibiotic therapy
 - iv. Confirmed VAD-related sepsis
 - (j) Catheters not removed after confirmed VAD-related infection have a higher risk of recurrent VAD infection.
- e) Damaged catheter
- (1) Etiology: Catheter dislodged from port septum; external portion of catheter sheared or fractured by powerful flush; catheter cut with scissors or clamps; disruption of skin integrity over port exposing portal body through the skin (Gallieni et al., 2008)
 - (2) Symptoms: Visible leak, moist dressing, pain, edema, visible port body
 - (3) Diagnostic tests: Chest x-ray or cathetergram to visualize catheter
 - (4) Clinical interventions (Gallieni et al., 2008)
 - (a) If a catheter is separated from a port body or internally damaged, the VAD must be removed. Repair is possible if damage or separation occurred with a two-piece attachable design (e.g., implantable ports).
 - (b) If nontunneled catheter is damaged, replace it using an over-the-

guidewire exchange. Some external portions of PICCs can be repaired with the manufacturer's repair kit.

- (c) If the external portion of a tunneled catheter (single- or multi-lumen design) is damaged, catheter can be repaired using the manufacturer's repair kit.
 - (d) If port body becomes exposed through the skin, the port should be removed.
- f) Extravasation (Polovich et al., 2009)
- (1) Etiology: Peripheral vein wall puncture, administration of a vesicant in a vein below a recent venipuncture, inadequately secured IV catheter, incomplete port needle insertion, dislodged needle from port septum, separation of catheter from port body, deeply implanted port, damaged long-term catheter in the SC tunnel, catheter tip migration outside venous system and backtracking of drug along tunnel resulting from a fibrin sheath (Hadaway, 2004; Rosenthal, 2007; Schulmeister, 2007, 2008)
 - (2) Prevention
 - (a) Select a needle length that will be adequate to pierce septum and secure in port septum.
 - (b) Decrease the likelihood of needle dislodgment from ports by needle stabilization and using nonsiliconized, noncoring needles for access (Schulmeister & Camp-Sorrell, 2000).
 - (c) Frequently check VAD exit site and for a blood return during vesicant administration.
 - (d) Teach the patient to report any symptoms.
 - (3) Symptoms (see Figure 12): Redness, edema, pain, burning, and absence of blood return during or following infusion, difficulty infusing solution, leaking around the IV catheter or implanted port
 - (4) Clinical interventions: Stop infusion; aspirate residual drug from the IV device or port needle using a 3 ml syringe; remove IV or port needle; assess site of suspected extravasation; estimate amount of extravasated drug; give antidote if indicated; apply cold or heat as indicated; determine cause;

Figure 12. Doxorubicin-Associated Extravasation



Photo a: Ulceration 8 weeks after doxorubicin administration



Photo b: Surgical debridement



Photo c: Surgical resection 12 weeks post initial extravasation

Note. From "Chemotherapy Extravasation From Implanted Ports," by L. Schulmeister and D. Camp-Sorrell, 2000, *Oncology Nursing Forum*, 27, p. 535. Copyright 2000 by Oncology Nursing Society. Reprinted with permission.

notify physician; observe site regularly; measure and photograph site; and document (Schulmeister, 2007).

- (5) Avoid giving vesicants through a VAD without a blood return. Catheter must be confirmed to be in correct position, intact, and patent (Camp-Sorrell, 2007; Schulmeister, 2008).
 - (a) Have the patient change positions, and flush catheter in attempt to obtain blood return.
 - (b) Flush catheter with push-pull technique.
 - (c) Try to declot catheter if clot is suspected.
 - (d) Confirm placement and intactness by cathetergram or Doppler.
 - (e) Obtain physician order to use catheter if needle is correctly in place and catheter patency is confirmed.
 - (f) Ensure that the patient is informed of symptoms of extravasation.
- g) Phlebitis (Rosenthal, 2006)
 - (1) Etiology
 - (a) Mechanical irritation or injury to vein wall, which may occur from insertion or by the presence or movement of catheter within the vein
 - (b) Chemical irritation from high acidity (vancomycin, amikacin) or alkalinity (sodium bicarbonate, ampicillin) of solution, from irritant drugs, and from infusates high in osmolality, such as parenteral nutrition
 - (c) Chemical irritation during insertion of catheter before cleansing solution is allowed to dry

(2) Symptoms: Redness, swelling, induration, pain, tenderness, presence of venous cord

(3) Clinical interventions

- (a) Rest and elevate extremity and apply warm compresses to affected area several times per day.
- (b) If symptoms do not resolve in 48–72 hours, catheter may have to be removed.

h) Infiltration (INS, 2006)

(1) Etiology: The inadvertent leakage of a nonvesicant medication into the tissue surrounding a venous access device

(2) Symptoms

- (a) Diminished flow rate of infusate as fluid accumulates in SC tissue
- (b) Coolness of skin, edema, pain or discomfort at infiltration site, leaking fluid at site, no blood return from device

(3) Clinical interventions

- (a) Prevention: Early recognition of potential infusion complication, sequencing medications appropriately (i.e., vesicants first), and diligent monitoring of venous access sites and devices
- (b) Remove device.
- (c) Evaluate for extent of infiltration using standardized measurement of infiltration scale.
- (d) Monitor site of infiltration for further complications, including nerve damage or compartment syndrome.
- (e) Educate the patient to notify caregiver of signs of difficulty with infusion.