NURSING PRACTICE & SKILL

Vascular Access Devices: Assessing to Reduce Risk of Complications

What is Performing an Assessment to Reduce the Risk of Complications for Vascular Access Devices?

› The function of a vascular access device (VAD) is to permit access to the venous circulation **(Figures 1, 2)** without the necessity of repeated venipuncture. There are many different types of VADs, including peripheral and central catheters, tunneled and nontunneled catheters, and VADs with implanted and nonimplanted ports. The proximal tip of a VAD catheter can terminate in the central or peripheral venous system. Depending on the device, the patient's needs, and the facility protocol, VADs can remain in place for days, weeks, months, and even years. The focus of this paper is about performing an assessment to reduce the risk of complications that are associated with VADs. For information about providing care for patients with VADs, see the series of *Nursing Practice & Skills* about peripheral and central VADs

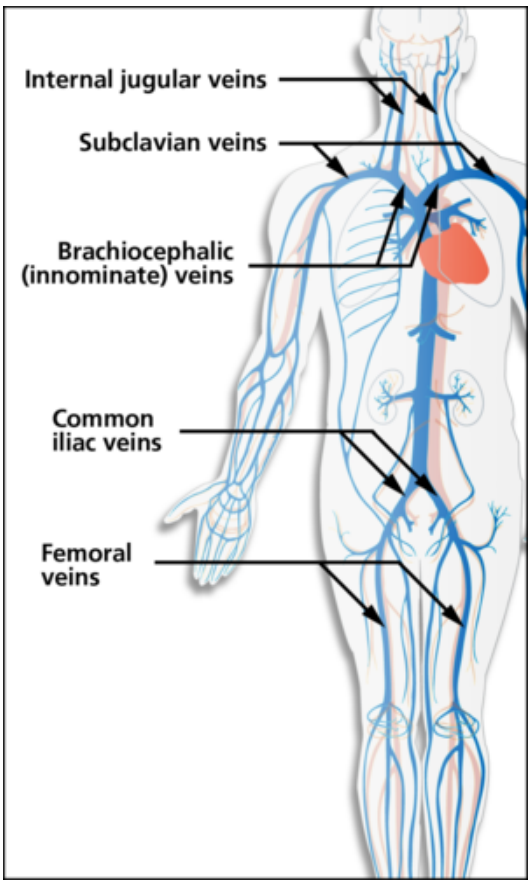

Figure 1: Major veins of the central venous system commonly accessed by central venous catheters. This image is in the public domain

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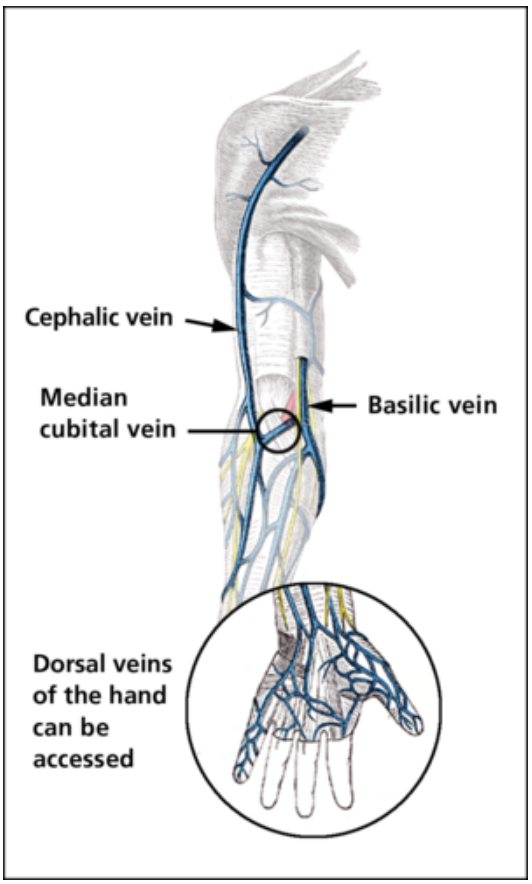

Figure 2: Peripheral veins commonly accessed for venipuncture. This image is in the public domain in the United States

- *What*: Typically, nursing responsibilities associated with assessment of VADs include
  - evaluating the insertion site or, in the case of implanted VADs, evaluating the skin and underlying tissue for signs and symptoms of localized infection, infiltration, and other abnormalities
  - evaluating the vasculature accessed by the VAD for signs and symptoms of phlebitis, occlusion, and other complications
  - monitoring the patient for systemic complications
  - evaluating the VAD for occlusion or damage
- *How*: Nursing assessment is performed by direct patient contact at routine intervals in accordance with facility/unit protocol and as required by patient circumstances. Physical interventions are performed using general aseptic nontouch technique (ANTT; i.e., a form of aseptic technique that utilizes strategies to prevent the sterile part of the equipment or medication/solution from coming in contact with anything that is not sterile prior to introduction in the patient)
- *Where*: Monitoring VADs to reduce the risk of complications is performed in all healthcare settings in which these devices are used, including inpatient, outpatient, and home care settings
- *Who*: Assessment of the VAD is generally the responsibility of a registered nurse. Appropriately trained staff members can assist with notifying the registered nurse of malfunction of the infusion pump and indications of possible infiltration or displacement of the VAD, if applicable. Patients and/or family members should be given special education and training if the VAD is to be utilized in the home setting

What is the Desired Outcome of Performing an Assessment to Reduce the Risk of Complications for Vascular Access Devices?

› The desired outcome of regularly assessing a VAD is that the device will remain functional and that complications will be detected promptly and resolved without undue injury to the patient

Why is Performing an Assessment to Reduce the Risk of Complications for Vascular Access Devices Important?

› Regular assessment of VADs is important because failure to perform timely assessment of VADs can result in potentially life-threatening complications (e.g., sepsis)

› Frequent assessment of VADs is important to verify proper functioning of the device and to detect complications promptly in order to limit or prevent
  • patient injury
  • a delay in treatment due to an occluded or damaged catheter
  • potential pain that is associated with catheter replacement
  • increased costs associated with catheter-related infection and/or dysfunction

Facts and Figures

› Infection is the most common complication associated with VADs. The United States Centers for Disease Control and Prevention (CDC) reports that the organisms most commonly involved in central venous catheter (CVC)-relatedinfections are *Staphylococcus aureus*, coagulase-negativestaphylococci, enterococci, and *Candida* (O'Grady et al., 2011)
› Researchers who have investigated CVC-related infections report that
  • 5–26% of patients with a CVC develop an infectious complication (Khouli et al., 2011)
  • an estimated 41,000 catheter-related bloodstream infections (CRBSIs) occur in hospitals in the U.S. each year (CDC, 2012)
  • CRBSIs are fatal in 16–35% of cases (Smith et al., 2011)
  • costs associated with CRBSIs in the U.S. are $28,690–56,000 per infection (Kim et al., 2011)
  • risk for CVC-related infection increases with the number of catheter lumens and dwell time. Contamination of the skin-catheter junction is the primary cause of infection that occurs within 7 days of insertion, and contamination of the CVC access port or catheter hub is the most frequent cause of infection from CVCs with > 7 days dwell time (Moureau et al., 2010)
› The United States National Quality Forum recommends that hospitals implement a group of evidence-based actions known as CRBSI care bundles to decrease CVC-related infections, promote the standards of care, and improve patient care and clinical outcomes(Strootman, 2014)
  • New Zealand researchers found that implementing a central line-associated bacteremia (CLAB) checklist to document nursing and medical compliance with insertion and maintenance of the central line reduces the rate of CLAB in high-risk patients who are admitted to the critical care unit (Hocking et al., 2013)
› Investigators who surveyed hospitalized patients with a CVC to determine patient awareness regarding CRBSIs and related complications reported that 40% of patients stated that education regarding infection could be improved, 22% could not recall being informed about infection risk, and 46% recalled receiving written information about CRBSIs. The researchers emphasized the need for improvement in patient education about CRBSI and infection prevention efforts(Anderson et al., 2013)

What You Need to Know Before Performing an Assessment to Reduce the Risk of Complications for Vascular Access Devices

› Prior to assessing a VAD to reduce the risk of complications, the nurse clinician should be familiar with the following:
  • Anatomy of the cardiovascular system, particularly the location of the most commonly accessed veins **(Figures 1, 2)**. Central veins that are most commonly accessed via tunneled and nontunneled catheters include the subclavian, internal jugular, and femoral. The catheters are threaded through the central venous vasculature until the proximal tip of the catheter reaches the junction of the superior vena cava and the right atrium (i.e., cavoatrial junction; **Figure 3**). The basilic, cephalic, and brachial veins are the most commonly accessed peripheral veins in adults. Peripherally inserted central catheters (PICCs) are usually placed in the same veins as short and midline peripheral catheters but are threaded through the venous system until the proximal tip reaches the cavoatrial junction

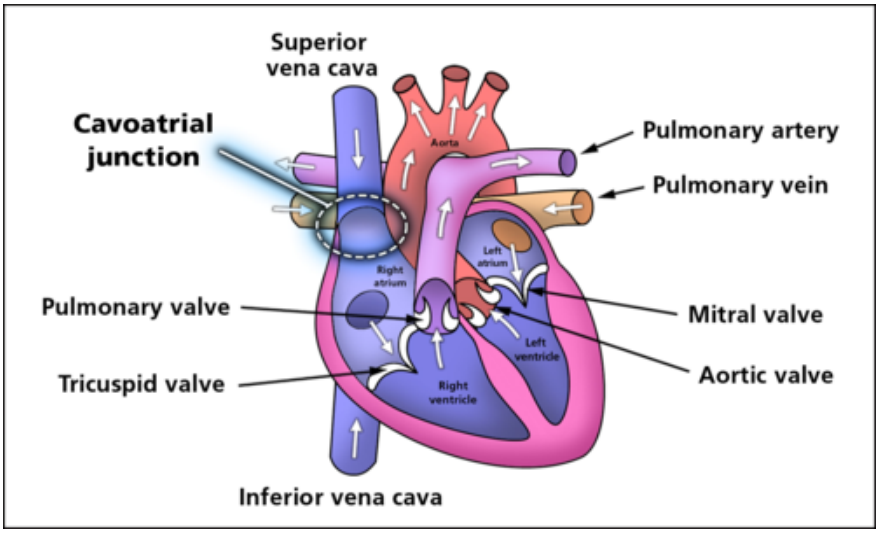

Figure 3: Anatomical image of the human heart, highlighting the cavoatrial junction.

- The type of VAD being assessed (e.g., short peripheral or midline catheter; a central venous catheter with or without an implanted port) **(Figures 4, 5, 6)**. For an overview of the types of CVCs, see *Nursing Practice & Skill ... Central Venous Catheters: Using — an Overview*

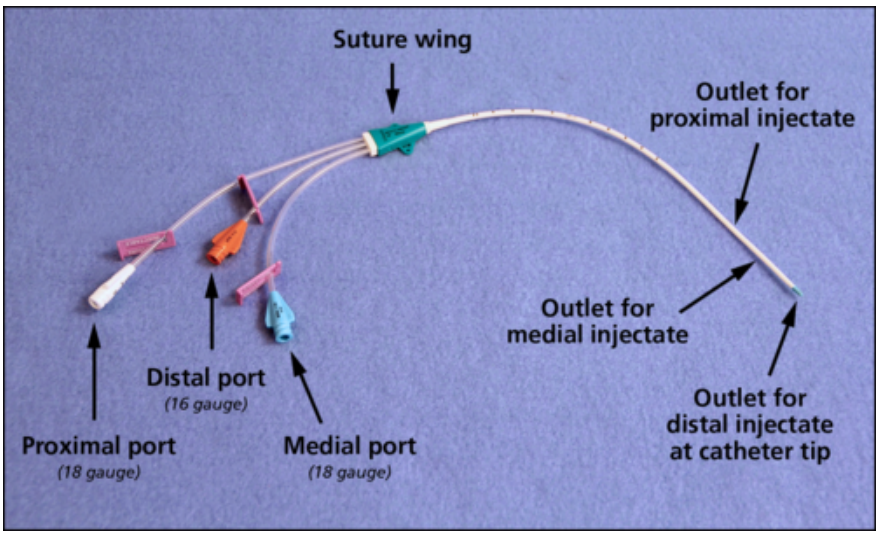

Figure 4: Triple-lumen intravenous catheter.

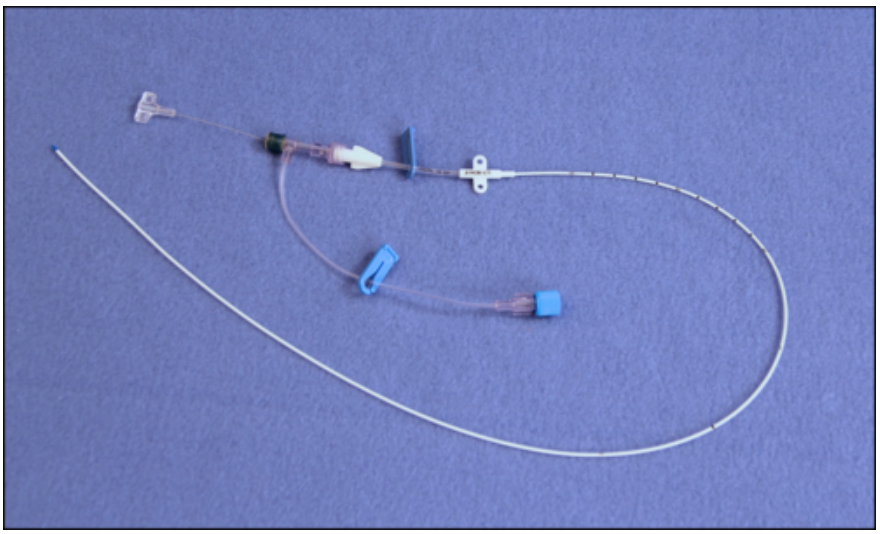

Figure 5: **P**ercutaneously **I**nserted **C**entral Catheter (PICC) 4 Fr with stylet.

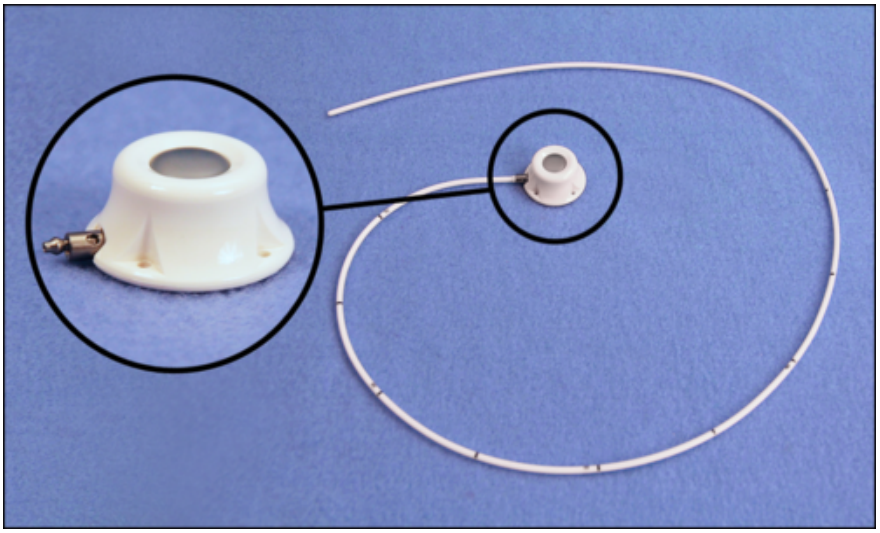

Figure 6: Port-A-Cath, port with catheter attached. Copyright© 2014, EBSCO Information Services.

- Correct aseptic technique should be utilized when manipulating the VAD (e.g., removing the dressing if necessary to visualize the insertion site, flushing the catheter to check for patency). For information about guidelines to reduce the rate of CRBSIs, see *Evidence-Based Care Sheet ... Catheter-Related Bloodstream Infections (CRBSIs): Guidelines for Prevention*
  - Knowledge of the facility-approved antiseptic and method of cleansing the access port prior to use is important. **The CDC has established a protocol requiring that the hub of the catheter (i.e., needleless connector or port) be vigorously scrubbed—not wiped—for 15 seconds with alcohol or chlorhexidine gluconate (CHG) with a new antiseptic wipeeach time it is accessed.** The "Scrub the Hub" recommendation is supported by the joint practice commissions of the Society for Healthcare Epidemiology of America (SHEA) and the Infectious Diseases Society of America (IDSA) (CDC, n.d.)
- Complications associated with I.V. cannulas, which include (see ***Red Flags*** , below, for additional information about complications)
  - infection, which is suspected in all patients with an I.V. cannula who develop fever, chills, and increased WBC count or redness, swelling, pain, bleeding, or exudate at the I.V. insertion site. Indwelling catheters (e.g., tunneled catheters and implanted ports) have less risk of infection than nontunneled catheters
    - Microbial contamination can result in colonization of the I.V. insertion site, localized or systemic infection (e.g., CRBSI), and other potentially life-threatening conditions (for details, see ***Red Flags*** , below)
  - infiltration (i.e., spread of I.V. fluid to surrounding tissues as a result of puncture of the vein wall during catheter insertion or subsequent catheter dislodgement from the intima of the vein). Signs and symptoms include swelling, discomfort, burning, tightness, blanching, and/or coolness of the surrounding skin area; inability to obtain blood return; and sluggish infusion
  - phlebitis (i.e., inflammation of the vein that can involve infiltration of the internal walls of the vein and/or formation of a thrombus, both of which can occlude venous blood flow), which is most prevalent in peripheral veins. This condition, known as thrombophlebitis or venous thrombosis, can involve superficial veins (superficial thrombophlebitis) and be painful but not severe (e.g., most typically occur in patients with varicose veins, patients who are pregnant, or patients on prolonged bed rest). Thrombophlebitis that involves a more deeply embedded blood vessel (deep thrombophlebitis) can be life-threatening if the thrombus breaks away and travels to the lungs (i.e., pulmonary embolism)
    - Signs and symptoms of phlebitis at or near the catheter site or along the path of the vein can include
      - a low-grade fever
      - pain/throbbing, tenderness, and warmth/burning
      - itchy skin
      - swelling compared with the opposite extremity
      - streaks of red following the path of the vein
      - discoloration (e.g., more pale or blue than pink, depending on skin tone)
      - a hardened, palpable venous cord
  - failure of the integrity of the I.V. catheter due to

- occlusion in the catheter tubing resulting from blockage (e.g., from formation of a thrombus or interaction of medication) or kinking in the catheter tubing. Catheter occlusion should be suspected when an infusion becomes slowed. Life-threatening conditions can develop if a thrombus or other type of material is dislodged in the bloodstream
  - The incidence of blockage can be reduced with regular flushing of the I.V. cannula with heparin or normal saline. Although heparin will not lyse existing clots because it has no fibrinolytic activity, regular (e.g., daily) flushing with heparin will reduce the thrombogenic properties of the catheter (i.e., the tendency of a material to produce a clot when it comes in contact with blood)
  - A kinked catheter can require repositioning or, if repositioning is unsuccessful, replacement of the entire catheter
- migration of the tip of the CVC beyond the point of its original placement. Resulting complications can include trauma and cardiac arrhythmias. Retrograde migration (i.e., coiling of the proximal tip without change in the length of the catheter extending from the insertion site) can occur
- breakage or cutting of the catheter, which is more common to midline catheters or CVCs. The catheter should be clamped only over the reinforced portion of the catheter by the clamp attached to the catheter by the manufacturer. If the attached clamp is missing, a padded hemostatic clamp (also known as a hemostat or Pean clamp) should be used. An unpadded metal clamp is likely to cut or crack the catheter and its use should be avoided

– introduction of an air embolus in the bloodstream during tubing changes or removal as a result of
  - inadvertent opening, cutting, or breaking of the catheter
  - improper flushing technique
– bleeding caused by inadvertent insertion of the catheter through the vein or into adjacent organs
– pneumothorax (i.e., collapsed lung), which occurs most frequently during transthoracic CVC placement
– pain at the insertion site or under the skin if the catheter has been tunneled

› The frequency of assessment will depend on the facility or unit-specificprotocol and the patient's condition. Although both the CDC and the INS have issued guidelines for the frequency of dressing changes, neither group has established recommendations for the frequency of assessment of the site and the catheter

• The position paper issued by the INS in 2012 recommended that peripheral catheter sites be assessed for redness, tenderness, swelling, drainage. and/or the presence of paresthesias, numbness, and tingling at a frequency ranging from every four hours to every 5–10 minutes depending on the patient's condition and the type of solution being infused (for more information regarding the frequency of assessment, see the INS position paper *Recommendations for Frequency of Assessment of the Short Peripheral Catheter Site* at http://www.ins1.org/files/public/07_05_12_Assessment_Position_Paper_BOD_FINAL.pdf)

› Except during transfusions, cannulas should not be filled with blood due to the risk of thrombus formation and subsequent catheter obstruction. The catheter should be flushed regularly to maintain patency and reduce the risk of obstruction due to blood clots, protein buildup, and fibrin. (For more information, see *Nursing Practice & Skill ... Central Venous Catheter Care: Lumen –Flushing*)

• The use of preservative-free normal saline (NS; i.e., 0.9% sodium chloride in sterile water) for a flush solution is well-established.The conclusions of the authors of three meta-analyses of randomized controlled trials agreed that intermittent flushing with heparin sodium (e.g., 100 units/mL) is equivalent to flushing with NS (Goode et al., 1991; Peterson et al., 1991 Randolph et al., 1998)

• The guidelines and practices for the frequency and flush solution vary according to the type of catheter

– The Infusion Nurses Society (INS) recommends flushing lumens with NS as a standard of practice. If NS is incompatible with medication, 5% dextrose in water should be used and followed by NS or a heparin solution (INS, 2011). Many facility protocols require that catheters be flushed every 8 hours when not in use, and flushed before and after each use with either NS or heparin. Nurses should review facility protocols to determine the frequency, the appropriate flush solution and volume, and, if heparin is to be used, the number of units of heparin to be instilled per flush
– The manufacturers of Hickman, Broviac, and Hickman-Broviaccatheters recommend using the S.A.S.H protocol (i.e., flushing the port with a designated volume of ***s*** aline, ***a*** dditive [e.g., medication, fluid], ***s*** aline, and ***h*** eparin [100 units/mL]) for flushing the catheter line. The S.A.S.H. protocol requires cleaning the hub (i.e., end of the VAD that connects the blood lines or cap of the administration set) 4 times
– The manufacturers of the Groshong catheter recommend use of a normal saline flush. Some manufacturers of implanted ports and open-ended catheter lumens recommend the use of heparin flushes in a range of concentration between 50 and 500 units/mL and flushing unused cannulas every 8 hours.
– If the catheter is used to draw blood for laboratory analysis, verifying that the line is flushed after the blood draw and that the blue end cap of Hickman catheters is replaced after each use is important

  - If the catheter is open-ended, the use of a positive pressure flush is recommended in order to create positive pressure in the catheter to prevent blood from backing up in the catheter. By maintaining positive pressure, flush solution is directed toward the proximal end of the lumen as the syringe is removed from the port. The positive pressure flushing technique requires that
    - when using a needle or blunt cannula, the syringe/needle or blunt cannula be withdrawn from the port as the last 0.5 mL of irrigant is expelled from the syringe. The line should be clamped before removing the syringe
    - when using a Luer-lock device, the catheter is clamped as the last 0.5 mL is expelled from the syringe
- The CDC/HICPAC guidelines recommend that an antiseptic solution composed of > 0.5% CHG with alcohol be used to cleanse the skin prior to catheter insertion, during dressing changes, and to clean injection ports before accessing catheters (O'Grady et al., 2011). If CHG is contraindicated, tincture of iodine, an iodophor, or 70% alcohol can be used as an alternative
- Preliminary steps that should be performed before performing an assessment to reduce the risk of complications for VADs include the following:
  - Review the facility or unit-specific protocols regarding assessment and patient care associated with VADs, if these are available
  - Review the treating clinician's order regarding care of the VAD, especially if nonstandard flush solution is ordered. Typically no order exists for assessment of a VAD and nursing assessment for a VAD is covered under the terms of facility or unit-specificprotocols
  - Review the manufacturer instructions for the vascular access device in use, as necessary
  - Review the patient's medical history/medical record for any allergies (e.g., to latex, medications, or other substances); use alternative materials, as appropriate
- Gather supplies necessary to perform an assessment of the VAD and the related patient assessment, which typically include the following:
  - Nonsterile gloves; additional personal protective equipment (PPE; e.g., gown, cap, mask, eye protection) may be necessary depending on facility/unit protocol and the potential for exposure to body fluids. A pair of sterile gloves will be required if dressing change is necessary
  - Facility-approved pain assessment tool
  - Prescribed analgesia and means for its administration (e.g., a glass of water for oral analgesia)
  - Equipment to measure vital signs
  - Facility-approved antiseptic swabs (e.g., CHG, povidone-iodine)
  - Alcohol swab(s)
  - Vial or prefilled syringe of NS or designated flush solution
    - Syringe and hypodermic needle if needleless equipment and prefilled syringes are not available
  - Syringe and hypodermic needle (if needleless equipment and prefilled syringes are not available)
  - Dressing supplies if removal of the dressing is necessary to visualize the insertion site and catheter (for a detailed listing of supplies, see the series of *Nursing Practice & Skills* regarding dressing changes for I.V. catheters). Typical supplies include the following:
    - Dressing (e.g., a semi-permeable transparent occlusive dressing such as Tegaderm
    - Gauze and tape
    - Skin preparation wipe (e.g., Benzoin). Skin prep helps reduce skin irritation resulting from adhesive-backed products and promotes adherence of the dressing when the patient is diaphoretic

How to Perform an Assessment to Reduce the Risk of Complications from Vascular Access Devices

- Perform hand hygiene
- Identify the patient according to facility protocol
- Establish privacy by closing the door to the patient's room and/or drawing the curtain surrounding the patient's bed
- Introduce yourself to the patient and family member(s), if present, and explain your clinical role; assess for knowledge deficits and anxiety regarding VADs and provide emotional support and additional information as needed
  - Determine if the patient/family requires special considerations regarding communication (e.g., due to illiteracy, language barriers, or deafness); make arrangements to meet these needs if they are present
    - Use a professional certified medical interpreter, either in person or via telephone, when a language barrier exists
  - Explain the procedure for assessing the VAD and its purpose

› Don nonsterile gloves (and mask if indicated by facility/unit protocol); don other PPE if exposure to body fluids is anticipated
› Raise the bed to a height that offers optimal access to the patient
› Position the patient to reduce risk of contamination from oral or pharyngeal bacteria is reduced (e.g., ask the patient to turn his or her head away from the catheter insertion site)
› Assess the patient's general health status, including vital signs and pain level using a facility-approved pain assessment tool; be alert to alterations in vital signs that could indicate infection such as fever (i.e., > 100.4 °F/38 °C [oral] or 101.4 °F/38.5 °C [rectal])
  • Administer prescribed analgesia as appropriate
› Inspect the I.V. site for bleeding; signs and symptoms of infiltration as evidenced by swelling, discomfort, burning, tightness, blanching, and/or coolness; and signs and symptoms of infection as noted by pain/tenderness, redness, swelling, warmth, and/or exudate
  • The guidelines published by the CDC recommend at minimum daily evaluation of peripheral catheter insertion sites by visual inspection and palpation through the dressing (if a transparent semipermeable membrane type of dressing is used) or whenever indicated by circumstances or patient report. If an opaque dressing is in place, it should be removed to permit visual inspection, especially if the patient reports the presence of tenderness (O'Grady et al., 2011). (For more information, see *Nursing Practice & Skill ... Central Venous Catheter Care: Dressing Changes*)
  • Peripheral catheters must be removed and a new catheter placed in a different vein if infiltration or infection is suspected or if it has been in place > 72 hours. Notify the treating clinician if infiltration or infection is suspected
› Assess the catheter and skin around the insertion site for dislodgement and other compromise by visually inspecting and palpating the area to evaluate for erythema, swelling, drainage. Evaluate the catheter for
  • suture integrity if sutures were used to secure the catheter
  • the absence of cracks, kinks, or other signs of damage
  • migration. Measure the length of catheter extending from the insertion site and compare this measurement with previously recorded information. Be alert to signs of retrograde migration
› Confirm patency of the VAD according to facility/unit protocol. Use general ANTT if the protocol requires that the catheter be flushed and blood aspirated to confirm patency (for more information see *Nursing Practice & Skill...Central Venous Catheter Care: Lumen — Flushing* referenced above)
  • Perform a vigorous 15-second scrub of the hub of the catheter with a new antiseptic wipe each time it is accessed. Remember that the **S.A.S.H.** protocol requires the hub to be scrubbed 4 separate times
  • Do not force the flush solution into the line because it may cause the catheter to rupture
  • Use a positive pressure technique if the proximal end of the catheter is open ended
  • Check facility protocols before flushing a central venous device because doing so is prohibited in some facilities due to concerns about contamination
› Dispose of soiled materials and PPE, remove gloves, and perform hand hygiene
› If a dressing change is necessary, perform it in accordance with facility/unit protocols (or refer to the series of *Nursing Practice & Skills* about dressing changes for peripheral and central venous catheters); dispose of soiled gloves and perform hand hygiene after completing the dressing change
› Update the patient's plan of care and document performing the assessment of a VAD in the patient's medical record, including the following information:
  • Date and time of assessment
  • Patient assessment information, including the
    – patient's level of pain, if analgesia was given, and patient outcome
    – assessment of the insertion site and the status of the catheter's integrity and placement, including the length of the catheter extending from the insertion site, if applicable
      - If the catheter was flushed or blood was aspirated, document information regarding the type and volume of solution used to flush the catheter
  • Patient's response to the procedure, including if he/she reported having pain and other discomfort during and immediately after the assessment
  • Any abnormal findings, interventions performed, whether or not the treating clinician was notified, and patient outcome. The following conditions should be reported immediately to the treating clinician:
    – Signs or symptoms of infection or infiltration
    – Inadvertent removal or dislodgement of the catheter
    – Damage to sutures that secure the catheter to the patient

  - Signs suggesting problems with integrity of the catheter, including cracked or broken catheter tubing and fluid leaking from the catheter insertion site
- All patient/family education that was provided, including topics presented, response to education provided, plan for follow-upeducation, barriers to communication, and techniques that promoted successful communication

Other Tests, Treatments, or Procedures That May be Necessary Before or After Performing an Assessment to Reduce the Risk of Complications of Vascular Access Devices

› If the catheter is removed due to suspected infection
- the proximal end of the catheter is usually sent for culture analysis
- blood cultures and Gram stain may be ordered to assess for microbial infection. If infection is present, antimicrobial sensitivity testing will likely be performed to identify the most effective treatment for the infection, and the identified antimicrobial therapy will be prescribed and administered

› Other tests and treatment may be ordered depending on assessment outcome; in the event of
- occlusion/obstruction, a fibrinolytic agent may be ordered to lyse a clot
- suspected migration of the catheter, the catheter will be repositioned which may involve resuturing
- phlebitis, warm compresses will be applied to the site following catheter removal

What to Expect Before or After Performing an Assessment to Reduce the Risk of Complications of Vascular Access Devices

› The patient will not experience adverse effects from placement of the BAD and related assessment and care (for information on potential adverse effects, see ***Red Flags*** , below)

› ANTT will be observed throughout the VAD assessment and performance of related care

› The VAD will remain intact and function properly

Red Flags

› The primary concerns regarding use of VADs are local and/or systemic infection and catheter dislodgement. These complications are rare and if they develop, the treating clinician should be notified immediately, the patient should be monitored closely, and, if needed, appropriate life-support strategies should be initiated according to Advanced Cardiac Life Support (ACLS) guidelines
- Infection is suspected in all patients with a catheter who develop fever, chills, and increased WBC count or redness, swelling, pain, bleeding, or exudate at the catheter insertion site. Localized infection can lead to infection of the heart muscle or potentially life-threatening sepsis if not managed aggressively. Sepsis is suspected if the patient has fever or hypothermia, tachycardia, tachypnea, or evidence of inadequate blood flow to internal organs. Early and appropriate antibiotic treatment can prevent potential progression to **sepsis** and possible **death**
- Catheter dislodgement, especially involving forward movement, can lead to arrhythmias, cardiac tamponade, or other signs of cardiovascular distress (e.g., significantly increased heart rate or a drop in blood pressure can be caused by lacerations to the atria and/or ventricle or CVC entanglement in the tricuspid heart valve and can irritate the heart, causing arrhythmias or cardiac trauma)

› Bleeding at the insertion site can indicate trauma to blood vessels or surrounding tissue

What Do I Need to Tell the Patient/Patient's Family?

› Explain the need for regularly assessing the VAD to the patient/family and respond to their questions and concerns

› Ask the patient/family to promptly report pain, swelling, or redness at the venous catheter site to a healthcare professional because this may suggest catheter infiltration and/or infection

› Emphasize the importance of avoiding pulling or placing pressure on the VAD

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