Maintenance of Venous Access Devices in Patients With Neutropenia

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Most patients undergoing chemotherapy treatment will have some level of neutropenia. Neutrophils are the body’s primary mechanism to fight bacterial infection. In a healthy host, neutrophils eliminate most bacteria adequately through phagocytosis. Chemotherapy destroys neutrophils, therefore weakening the body’s ability to defend itself against bacteria. The National Cancer Institute classifies neutropenia into grades 1–4. Mild neutropenia (grade 1) is present in patients with an absolute neutrophil count (ANC) of less than 2,000/mm³. Profound neutropenia (grade 4) is an ANC of less than 500/mm³. The type of malignancy (solid versus hematologic), type of chemotherapy (including duration and timing), and general immune status prior to chemotherapy will determine the extent of neutropenia that patients will experience during treatment (Greene, 1996).

Neutropenia is a major risk factor for increased morbidity from infection in patients with cancer, so preventing infection is a priority. Because of the frequency of IV medication administration, the use of vesicants, and venipuncture discomfort, many patients have venous access devices (VADs). Although VADs are common, they give microorganisms easy entry into the bloodstream and can cause serious infection. Approximately 400,000 patients experience bloodstream infection from VADs each year (Viot, 2000). Of those patients, approximately 80,000 will die, and one-third of those deaths are directly attributed to the use of VADs (Viot). The rate is even higher in patients with neutropenia. A study by Elishoov, Or, Strauss, and Engelhard (1998) of patients undergoing bone marrow transplants found that 65% of VAD-related infections (VAD-RI) occurred during periods of neutropenia. The incidence of VAD-RI in neutropenic periods versus non-neutropenic periods was found to be almost two to one. Furthermore, 88% of infections occurring during neutropenia progressed to septicemia, whereas less than 10% progressed during non-neutropenic periods. Because treating VAD-RI costs more than $10,000, this is not only a dangerous complication for patients but also a costly one (Jackson, 2001). Despite early diagnosis and aggressive treatment, the mortality rate from nosocomial bloodstream infections related to VAD use remains significant (Viot).

Nurses caring for patients with VADs must understand catheter type, correct use and maintenance of VADs, and prevention and early detection of VAD-RI.

Overview of Venous Access Devices

VADs have been used for more than three decades to administer IV medications, nutrition, and blood products and to draw blood specimens. Three types of long-term VADs often are used in oncology: tunneled catheters, peripherally inserted central catheters (PICCs), and implanted ports. Although each device has distinguishable differences, they can be used similarly. The majority of VADs are made of silicone polyurethane material, and a variety of internal and external diameters are available. All devices are available with single or double lumens, and tunneled catheters are available with three lumens. Each device is available with an open distal tip or with a three-way valve creating a closed distal tip.

Each VAD has characteristics that help to decrease the risk of infection. Most PICCs are inserted in the antecubital fossa of the arm and threaded through the cephalic or basilic veins. The risk of infection is decreased because fewer organisms live on the arm than on the chest and the area is far away from the nose and mouth. Therefore, the chance of introducing organisms into the bloodstream through the VAD is diminished (Pearson, 1996). Tunneld catheters have a cuff to secure the catheter in a subcutaneous tunnel away from the insertion site. Both tunneling and the cuff help to prevent the migration of microorganisms into the bloodstream.


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Portal bodies of implanted ports are available in a wide variety of shapes, sizes, and materials. The portal body contains an internal reservoir covered with a septum made of a resealable silicone material. Once implanted, the portal body is sutured to the fascia within a port pocket. Ports have a lower infection risk because of their location beneath the skin, eliminating constant exposure to the external environment (Pearson, 1996).

Although VADs come in a variety of designs, the tip of any catheter is inserted into the superior vena cava above the right atrium junction. After insertion, all catheters should flush with ease and have an adequate blood return. Each device requires consistent care and maintenance to prevent untoward effects, such as thrombosis, accidental removal, or infection.

Maintaining Venous Access Devices

Prevention of VAD-RI is the best way to avoid costly and life-threatening complications in patients with neutropenia. Prevention strategies include using an aseptic technique when inserting and maintaining VADs, using an aseptic technique to prevent VAD contamination during routine care, and ensuring adequate education of patients and caregivers. Several factors can increase the risk of VAD-RI, including patient factors, catheter factors, and caregiver factors (see Figure 1). All must be considered when caring for patients with neutropenia who have VADs.

Numerous studies have examined the frequency of dressing changes, types of dressings, cleansing methods, and flushing protocols. However, many of the studies are 10–20 years old, and no consensus has been reached regarding VAD care. Many of these studies are compared and contrasted in Camp-Sorrell’s (1996) Access Device Guidelines: Recommendations for Practice and Education.

Hand washing is the easiest and most economical way to prevent infection in patients, regardless of immune status. It is even more essential in patients with neutropenia. Prior to any manipulation of VADs, nurses or caretakers should wash their hands, even if they intend to wear gloves or if gloves were just removed. Soap and water eradicate most organisms in 90 seconds. Alcohol-based, waterless hand sanitizers eradicate most organisms in 10–20 seconds (Stone, 2001). To encourage frequent hand washing, either soap and water or hand sanitizers must be available and easily accessible to all healthcare providers. Caregivers of patients with neutropenia should avoid wearing acrylic or other synthetic fingernails because they are more likely to harbor microorganisms, such as staphylococcus aureus, enterococcus, and fungal pathogens, than natural fingernails (Hedderwick, McNeil, Lyons, & Kaufman, 2000). Healthcare providers caring for patients with neutropenia must comply with frequent hand washing and maintain clean fingernails to reduce the risk of infection.

The best method for changing dressings and the best dressing material remain issues of debate. The purpose of any dressing should be to prevent microorganism contamination and proliferation at the exit site and to anchor the device to the skin, thus preventing accidental removal (Treston-Aurand, Olmstead, Allen-Bridson, & Craig, 1997). Although sterile dressings should be used to dress VAD exit sites, a sterile technique is not necessary. Because sterilizing skin is impossible, an aseptic technique, meaning without infection, is adequate. The majority of studies recommend the use of 70% alcohol and either povidone iodine in a 10% solution or chlorhexidine solution for exit-site care. Although chlorhexidine is the preferred solution, a convenient application swab currently is not available in the United States (Maki & Ringer, 1987). The technique most widely used is to apply the cleansing solution with gentle friction, making concentric circles from the exit site moving outward and repeating twice (Camp-Sorrell, 1996).

The use of antibiotic or iodine ointment at the exit site remains controversial. Although the use of such ointments might decrease the incidence of bacterial contamination, this has not been well established, and the ointments might even promote the growth of fungal contaminants (Pearson, 1996). Considering the incidence of fungal infections in the neutropenic population, it seems prudent to avoid routine use of these ointments.

Once exit-site cleansing is completed, a sterile dressing is applied. The use of tape and gauze dressing versus a transparent occlusive dressing continues to be an issue of debate. Both have advantages and disadvantages. A transparent dressing allows for visual inspection of the catheter site without removal of the dressing. Because it is occlusive and adheres to the skin and catheter, it provides stabilization and does not need to be changed as frequently. However, an occlusive dressing might trap moisture and provide a perfect environment for bacterial colonization. Also, a transparent occlusive dressing might cause excess skin irritation upon removal or might not adhere to diaphoretic patients (Dougherty, 1998). A tape and gauze dressing encourages air circulation as opposed to the transparent occlusive dressing, therefore decreasing the risk of bacterial colonization. A tape and gauze dressing is less expensive than a transparent occlusive dressing, but it must be changed more frequently, and visualization without removing the dressing is impossible (Ray, 1999).

Treston-Aurand et al. (1997) studied the rates of VAD-RI in non-neutropenic patients using a transparent occlusive dressing, tape and gauze, and a highly permeable transparent dressing. In this retrospective study of hospital-wide VAD-RI rates, 3,931 VADs were investigated. Transparent dressings were used on 880 VADs, 1,374 were dressed with tape and gauze, and 1,677 were dressed with a highly permeable transparent dressing. The researchers found that the transparent occlusive and highly permeable transparent dressings provided the best protection against VAD-RI. The tape and gauze method had a higher rate of bacterial contamination. Another retrospective study, by Rasero et al. (2000), found no difference between the occurrences of VAD-RI in neutropenic patients receiving bone marrow transplants who had sterile gauze dressings versus those who had transparent dressings.

**Figure 1. Factors That Increase the Risk of Venous Access Device-Related Infection**

Note. Based on information from Ray, 1999.
In a study of recipients of bone marrow transplants, patients with both tunneled and nontunneled VADs were not at an increased risk of infection with less frequent (every five days versus every two days) dressing changes. Furthermore, patients comfort increased and the cost of nursing care decreased (Rasero et al., 2000).

Despite the controversies about the types of cleansing solution and dressing material and the frequency of dressing changes, it is imperative to use a consistent procedure, conduct a full exit-site assessment, and document the condition of the surrounding skin integrity.

For patients with neutropenia, an aseptic technique is essential for VAD-site care. Gloves should be used, but the use of sterile gloves, masks, and gowns does not seem necessary as the majority of infections arise from the skin itself (Jackson, 2001; Mermet et al., 2001; Pearson, 1996; Raad, 1998; Ray, 1999; Treston-Aurand et al., 1997). Although staphylococcus aureus is colonized in the nasal passages, the organism transfers in droplets (Jackson). If a caregiver actively coughs or sneezes and another caregiver is not available, masking is necessary. To date, no studies confirm what is most appropriate for VAD-site care.

Catheter patency is maintained with routine flushing. Although the purpose of routine flushing is not to directly prevent VAD-RI, the risk is minimized indirectly by preventing thrombus and fibrin sheath formation. Saline and heparin solutions in various strengths and amounts are most commonly used to maintain VAD patency. Barriga et al. (1997) and Carratala et al. (1999) have investigated the routine use of antibiotic flush solutions and thrombolytic solutions to prevent VAD-RI secondary to thrombus. The antibiotic flush solutions, although effective in preventing some organism contamination on the internal catheter surface, have been associated with increased antibiotic resistance and allergic reactions (Ray, 1999). Thrombolytic solutions, such as streptokinase or tissue plasminogen activator, have also been used in some hospitals in an attempt to prevent thrombosis when used prophylactically on a routine basis (Ray). More studies must be conducted to fully assess the efficacy of antibiotic and thrombolytic solutions in routine flushing.

Catheter flushing might introduce microorganisms into a VAD through the catheter hub. Because the hub of a catheter is one of the major sources for contamination leading to VAD-RI (Mermel et al., 2001), an aseptic technique is essential when flushing, drawing blood specimens, or administering medications. The catheter hub should be cleansed vigorously with alcohol or povidone-iodine, and the needle or syringe used to enter the catheter should be sterile. A catheter hub cap should be changed—using an aseptic technique—at least once a week, or more frequently depending on catheter use. The thread end is cleansed with alcohol when the cap is changed. Tape should not be used to secure the cap because it might increase the risk of bacterial contamination (Jackson, 2001).

Although the method used to perform routine care for VADs varies from institution to institution, a general theme applies: All VADs require routine maintenance, and maintenance includes site care and flushing of the catheter lumen(s) at some established interval. VAD infection rates should be monitored closely for increasing numbers and types of infections. If a pattern of increased frequency emerges, an investigation into the practices of the healthcare providers should be conducted to identify the source of infection and, possibly, to change the institutional policy to correct the infection source.

**Classifications of Infections**

Despite careful and consistent VAD maintenance, infection remains the most common complication. To fully understand the etiology, pathogenesis, and treatment of VAD-RI, nurses should understand the different categories of infections. The Hospital Infection Control Practices Advisory Committee (HICPAC), in its guidelines for the Centers for Disease Control and Prevention, classified the various types of catheter-related infections into the following (Pearson, 1996).

- Catheter colonization
- Exit-site infection
- Bloodstream infection

Catheter colonization is defined as micro-organism growth found in a culture from the catheter tip or catheter hub. Exit-site infections can be clinical, tunnel, and port pocket infections. A clinical or local infection refers to phlebitis within 2 cm of the exit site, and a tunnel infection refers to phlebitis more than 2 cm from the exit site. A pocket infection, associated with an implanted device, is identified by the presence of infectious fluid in the port pocket. Inset 1 is an example of a port pocket infection. Infection of an exit site may or may not occur in conjunction with a bloodstream infection. Bloodstream infections can be either infusion related or catheter related. An infusion-related infection occurs when the same microorganism is identified in the bloodstream and in an infusion (Mermel et al., 2001). A catheter-related bloodstream infection is present when more than one positive blood culture is obtained peripherally or from the catheter with clinical signs of infection (Pearson, 1996). Although accessing an implantable port with signs of an infection to obtain blood cultures is controversial because of the risk of hematogenous seeding, if the infectious organism is not known, this procedure might be necessary to treat the patient effectively (Rumsey & Richardson, 1995). Another infectious complication not identified in HICPAC’s...
guidelines is a septic thrombus, an identified thrombus in the vein of the VAD in the presence of a bloodstream infection (Greene, 1996).

Some local signs and symptoms of VAD-RI vary from mild to severe and include redness, warmth, exit-site drainage, tissue necrosis, pain or tenderness, and spontaneous rupture of a port pocket. Systemic signs of infection include fever, chills, rigors, hypotension, and tachycardia (Gonzalez-Barca, Carratala, Mykietiuk, Fernandez-Sevilla, & Gudiol, 2001). These symptoms might not be definitive of VAD-RI and might appear more subtly, or not at all, in patients with neutropenia. Considering that these infections are life threatening, especially for patients with neutropenia, nurses must be able to assess for infectious symptoms and report them to healthcare teams to quickly implement appropriate interventions.

**Sources of Infection**

The three main sources of VAD-RI are the skin, catheter hubs, and hematogenous seeding. Skin and catheter hubs are the most common sources (Greene, 1996). Although a patient’s skin at the catheter insertion site is a frequent cause of infection, the hands of caregivers carry some of the most common infecting organisms, including coagulase negative staphylococcus, staphylococcus aureus, and candida species (Hanna, Raad, & Darouiche, 2001). Coagulase negative staphylococcus, usually staphylococcus epidermis, is the most common cause of bacteremia in patients with neutropenia, with skin being the most common bacteria source. Staphylococcus aureus infections are especially serious because other life-threatening complications can occur, including endocarditis, osteomyelitis, septic thrombosis and emboli, and fatal sepsis (Raad, 1998). Patients at high risk for candidal infections include those with histories of numerous antibiotics, steroid use, chemotherapy-induced neutropenia, and radiation therapy (Ray, 1999).

A catheter hub, or the external distal end of the catheter, also is a major source of VAD-RI. An implanted port does not have an external hub unless it is accessed, making it less susceptible to organism invasion. Contamination of a catheter hub can occur during routine flushing, manipulation of the catheter cap, cap changes, medication administration, or withdrawal of a blood specimen.

Hematogenous seeding is the migration of microorganisms from a distant infection to the VAD site. Although this occurrence is rare in the general population, hematogenous seeding of intestinal organisms in patients with neutropenia occurs frequently. Researchers believe that 50% of all candida infections are caused by microorganism migration from the gastrointestinal tract to the bloodstream via the mesenteric lymph nodes (Greene, 1996).

**Diagnostic Techniques of Infection**

Until recently, diagnosis of VAD-RI usually was made retrospectively when the catheter was removed and cultures were tested for microorganisms. Although this is a definitive diagnostic method, it interrupted therapy for patients undergoing immunosuppressive treatments, and VAD reinsertion put them at risk for hemorrhage and subsequent infection. Patients with ports had to undergo a minor surgical procedure for port removal. Today, many VAD-RI can be diagnosed and treated without catheter removal.

The suspected organism and location of infection determine the diagnostic technique used to identify the infecting organism and guide treatment (Mermel et al., 2001). Exit-site infections usually are diagnosed by taking cultures of any drainage noted at the exit site. Systemic signs of infection require blood cultures, preferably drawn through the VAD and peripherally. These cultures can be interpreted either paired (positive versus negative) or quantitatively (comparing numbers of organisms found in each culture). A new technique, called differential time to positivity, is used to interpret paired cultures by measuring the time it takes for a culture to become positive (Mermel et al.). Although a paired culture may be optimal for diagnosing VAD-RI, many patients with cancer have little to no peripheral venous access. In the absence of a peripheral culture specimen, a VAD culture showing greater than 100 colony forming units/mL is considered a positive culture (Mermel et al.).

In the event that a catheter must be removed because of a suspected infection, the catheter tip should be sent to a laboratory for culture. To remove VADs, practitioners should use an aseptic technique by cleansing patients’ skin with alcohol and carefully removing the devices to prevent contamination. If symptomatic, patients can show rapid improvement when infected VADs are removed (Jackson, 2001).

**Treatment of Infection**

Once VAD-RI is suspected in a patient with neutropenia and blood cultures are obtained, nurses should begin immediate aggressive therapy to prevent systemic sepsis. Because patients with neutropenia might not exhibit early signs of infection, they might be critically ill by the time infection is identified. Patients should be monitored closely for signs of sepsis, including hypotension, confusion, and elevated temperature. Therapy for immunocompromised patients might be very different from therapy for patients with healthy immune systems. Although saving catheters might be the goal in non-neutropenic patients, rapidly progressing organisms in neutropenic hosts might not be eradicated with systemic therapy alone, in which case VADs must be removed (Mermel et al., 2001). In this case, temporary devices may be placed. Local infections in healthy hosts may be treated with oral antibiotics and topical treatment; however, in patients with neutropenia, or if the infection is progressing, IV antibiotics are required and VADs should be removed (Ray, 1999).

The course of treatment also depends on the level of neutropenia. Patients who are profoundly neutropenic or undergoing ablative chemotherapy for stem cell transplant require more aggressive treatment than those who are only mildly neutropenic. The duration of antibiotic use generally is 14 days with vancomycin, penicillin, or third-generation cephalosporin.

Because the majority of infections are skin related, infections should be treated empirically as such until definitive cultures and sensitivity results are available. Whether a VAD is removed or salvaged, the treatment usually is the same. Once cultures and sensitivities are completed, adjustments in antibiotic regimens are made to appropriately eradicate infecting organisms.

In the case of septic thrombophlebitis, concurrent thrombolytic and antibiotic therapy is controversial because of the risk of septic emboli. VADs should be removed, and patients should receive long-term IV antibiotic and anticoagulation therapy for six weeks or more (Ray, 1999).

**Summary**

Maintenance of VADs remains an important issue for nurses caring for patients with cancer. Preventing infection in patients with neutropenia is a priority. Physicians and nurses who insert and maintain catheters need to be educated with current information guiding their practice. A standard policy and procedure for maintaining VADs and
preventing infection should be established and reviewed frequently. Additionally, VAD infections should be monitored and investigated for potential sources. Patients and caregivers should learn the proper procedures through written materials, videos, and personal teaching sessions. Educating caregivers is vital to the maintenance of VADs and should begin prior to or as soon as appropriate after placement.

Although VADs have been used for more than 30 years, no universal standard of care exists to prevent infections, especially in patients with neutropenia. Continued investigation is needed into the use of antibiotic flush solutions, topical ointments, and dressing materials and their use in the neutropenic population. Research is needed to establish a scientific basis for VAD care, not only in patients with cancer but in patients with neutropenia as well.

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References
Antimicrobial Agents and Chemotherapy, 43, 2200–2204.

For more information on this topic, visit the following Web sites.
National Institutes of Health Clinical Center Nursing Department: Care of the Severely Neutropenic Patient www.cc.nih.gov/nursing/neutsop.html
Society of Vascular Technology www.svtnet.org

These Web sites are provided for information only. Hosts are responsible for their own content and availability. Links can be found using ONS Online at www.ons.org.

Rapid Recap
Maintenance of Venous Access Devices in Patients With Neutropenia
• Venous access devices (VADs) are a costly and possibly fatal source of infection in patients with neutropenia. The risk of infection depends on several factors, including the type of VAD used, site of insertion, number of catheter lumens, immune status of the patient, and maintenance of the VAD.
• The three main types of VAD-related infections (VAD-RI) include catheter colonization, exit-site infection, and bloodstream infection.
• The three most common pathogens that cause VAD-RI are staphylococcus epidermis, staphylococcus aureus, and candida species.
• Treatment options for VAD-RI include topical, oral, or IV antibiotics and thrombolytics, as well as VAD removal.
• More research is needed to establish a standard for routine maintenance of VADs in patients with neutropenia and patients with cancer.
• Patients and caregivers should be educated about how to care for their VADs and how to identify an infection.