Complications of Central Vascular Access Devices

Central vascular access devices, or central venous access devices (CVADs), are fundamental in the nursing care of the critically ill, those with chronic conditions (oncological needs, renal failure), and emergency care. CVADs include central venous catheters, implanted ports, hemodialysis catheters, umbilical catheters, central apheresis catheters, and PICC lines. CVADs provide numerous advantages and require specialized care and precautions.

Nurses must institute preventive measures against CVAD complications, be vigilant and stay alert to signs and symptoms of complications when caring for patients with CVADs and be prepared to intervene when complications are suspected. Avoiding complications begins with proper device selection and placement. The Infusion Nurses Society (INS) 2016 infusion standards of practice recommend the use of the smallest device, with the fewest lumens, and the least invasive device type required, to be maintained for the shortest duration possible (Gorski et al., 2016). The use of standard precautions, aseptic technique, maintaining a sterile dressing, complying with institution-specific site care, and adhering to proper cleaning of needleless connectors and flushing protocols applies to all vascular access devices.

Infiltration/Extravasation

Infiltration refers to the leaking of intravenous (IV) fluid or nonvesicant medication into the tissue surrounding a vascular access device. Extravasation refers to the leaking of vesicant drugs into the tissue surrounding a vascular access device.

Causes

- Improper access of a CVAD (an implanted port, for example)
- Fractured/damaged device below the skin
- Dislodgement of a CVAD through patient movement
- Improper device placement
- Distal occlusion of the catheter causing retrograde infusion

Signs and symptoms

- Leakage from the insertion site
- Blisters near the access site (as the extravasated drug affects local tissue)
- Firmness of the area surrounding the CVAD entry point

Additional signs of extravasation from a CVAD may be as subtle as edema or a raised area of the neck or chest. Extravasations into deep tissue may produce no visible signs, therefore complaints of pressure or pain near a CVAD insertion site from an awake patient must be recognized as an important sign of possible CVAD complication.
Prevention

- Careful assessment prior to and during flushing and/or administration of medications through a CVAD include observation, palpation, checking for blood return, and ease of flushing. Any patient report of pain at site or with injection should prompt further evaluation.

Management

- Immediately stop infusions to the CVAD at first sign of complication and establish other access if life sustaining medication is required.
- Estimate the amount and type of infiltrated or extravasated solution and notify prescriber.
- Record and mark infiltration/extravasation site, patient symptoms, estimated amount/type, and treatment rendered.
- Follow institution or manufacturer specific treatment protocol (cold versus warm compress or injection of antidote). Notify the prescribing licensed independent practitioner (LIP) to update and discuss the plan of treatment with a goal of limiting damage to local tissue.

Occlusion

CVAD occlusion refers to the inability to infuse through or flush the catheter without resistance and the inability to elicit a blood return.

Causes

- External mechanical crimping of device at insertion site
- Migration of catheter out of optimal position
- Chemical precipitate in device
- Distal thrombosis
- Intraluminal thrombosis

Signs and symptoms

- Inability to withdraw blood from a CVAD or sluggish blood return
- Sluggish flow or frequent occlusion/high pressure alarms on electronic infusion devices
- Inability to flush or infuse through a CVAD
- Patient report of “whooshing” or other sound when CVAD flushed (potential cephalad migration of catheter)

Prevention

- Use proper facility-approved flushing and locking protocols.
- Check for incompatibilities when infusing two or more drugs together.
- Identify drugs at high risk for causing precipitate in tubing/devices.
- Review result from radiographic studies of the arms, chest, and neck; note the location of the CVAD tip, if visible.
Use caution when using CVAD for blood draws, and use proper flushing techniques to maintain system patency.

Management

- Assess for external mechanical issues first, by troubleshooting needleless connectors, tubing, clamps, and infusion systems, as well as site/dressing for kinks or clamps that may be the source of occlusion.
- Resolve suspected mechanical or thrombotic occlusions early to maintain patency of system and avoid further complications. Utilize facility-approved catheter clearance agents in accordance with facility protocol.
- Do not leave a suspected CVAD occlusion untreated or leave a single lumen untreated when other lumens are still functioning.
- Consult LIP or vascular access specialist if malposition is suspected to evaluate CVAD tip position radiographically if necessary.

Nerve Injury

Nerve injury refers to compression of, or direct damage to nerve tracts within the body at or near a CVAD insertion site. Large blood vessels and nerves travel similar paths within the body, however anatomic variation is possible, increasing the possibility of temporary or permanent nerve damage when CVADs are placed.

Signs and symptoms

- Radiating electrical pain during insertion
- Paresthesia, tingling, burning, prickly feeling, or numbness after insertion
- Respiratory difficulty (with external jugular, internal jugular, or subclavian lines) after insertion due to phrenic nerve disruption
- Unusual presentation of pain or discomfort near insertion site
- Horner’s syndrome – unilateral miosis (pupillary constriction), partial ptosis (eyelid droop), and anhidrosis (lack of sweating on affected side of face) with disruption of cervical sympathetic nerves (can be due to insertion trauma or thrombus)

Prevention

- Early detection through neurovascular assessment of extremities with PICC lines, assessing for nerve injury symptoms which can be direct (as listed above) or indirect (such as with compartment syndrome or nerve compression from extravasation).

Management

- Early recognition and discussion with LIP/vascular access specialist to create alternate vascular access plan.
Infection

Infection refers to local or systemic signs of infection in patients with a CVAD in place.

Signs and symptoms (May vary widely based on type of CVAD)

- Pain, tenderness, or drainage at or near CVAD insertion site
- Subcutaneous fluid accumulation near an implanted site
- Induration, ulceration, or necrosis of tissue near CVAD insertion site
- Body temperature elevation

*Remember, that while many patients with CVADs are at high-risk for infection due to their co-morbid conditions such as ESRD, neutropenia or other critical illness, current research demonstrates CVADs should not routinely be removed based solely on body temperature elevation, without positive confirmation of catheter-related bloodstream infection (CR-BSI).*

Prevention

- The goal with CVADs is always prevention of infection, through strict adherence to standard precautions, site asepsis, maintenance of a sterile dressing site, proper lumen cleaning/care both before and after use, and patient education.
- Ensure strict adherence to facility policy for dressing care, as well as the timely changing of solution sets and infusions.

Management

- Early recognition of overt and subtle signs and symptoms is key.
- Monitor patient for hemodynamic stability.
- Collaborate with involved LIP to determine ability to salvage CVAD versus replace the CVAD whenever a CR-BSI is suspected.
- Alternate vascular access plans should be made in collaboration with the patient care team and patient/family wishes as appropriate.

Venous Air Embolism

A venous air embolism (VAE) is a rare but potentially fatal complication that may occur in 0.2-1% of central line placements and is due to air entering the venous system where it can travel to the heart and prevent forward motion of blood through the cardiac and pulmonary circuits. This phenomenon is most commonly associated with central line placement in the subclavian vein and due to changes in intrathoracic pressure related to normal breathing. VAE can also occur due to air entering lumens of already placed CVADs.

Signs and symptoms

Have a high degree of suspicion for a VAE in a CVAD patient with acute and sudden onset of:

- Dyspnea, continuous coughing, breathlessness, tachypnea, wheezing
- Chest pain, tachyarrhythmia, hypotension
• Altered speech, altered mental status, changes in facial appearance
• Numbness, paralysis
• Any other acute and sudden unexplained cardiopulmonary and neurological symptoms
• If intubated, there will be a sudden drop in end-tidal CO\textsubscript{2} noted on capnogram

**Prevention**
• Trace all lines back to patient and ensure tight/secure connections at all junctions of tubing as a routine part of your assessment.
• Verify that all air is purged from syringes, administration sets, needleless connectors, and other devices prior to connection to patient.
• Never use scissors, razors, or scalpels near CVADs.
• Use facility-approved technique/positioning for removal of CVADs and dress site in accordance with facility policy.

**Management**
• Acute VAE is a potentially fatal medical emergency and immediate recognition and action is required to prevent further harm.
• First, take whatever action is necessary to prevent further air from entering the patient vascular system, which may include covering the CVAD site with an air occlusive dressing, clamping an affected lumen/tubing, or covering the site of a recently removed CVAD.
• Concurrently call for help, initiating a code or rapid response if in acute care settings, or calling for emergency medical services if in a patient home or other care setting.
• Patient should be placed in Trendelenburg/left-lateral decubitus, or on left side/head down position if possible, to trap air in lower portion of right ventricle, preventing an air lock within the heart.
• Administer 100% oxygen if available, provide supportive care, and discuss patient management with patient care team.

**Catheter Damage/Rupture**
Damage can occur to CVADs due to trauma to the external portions of catheter such as contact with sharp objects. The internal portions can also be damaged due to forceful flushing or improper use of devices not intended for power injection.

**Signs and symptoms (related to the specific damage to CVAD)**
• Infiltration/extravasation
• Air entrainment/VAE
• Occult internal bleeding as blood refluxes out of damaged section into patient

**Prevention**
• Provide meticulous line care, vigilant observation, and routine assessment.
• Avoid use of sharp objects near CVAD sites.
• Use proper syringe size for flushing, and when assessing blood return (10ml size syringe barrel).

Management
• Intervene early, collaborating with the patient care team and vascular access specialist.

Thrombosis
A CVAD-associated venous thrombosis refers to a superficial or deep vein thrombosis along path of CVAD. Risk factors include history of DVT, acute critical illness, presence of genetic coagulation abnormalities, specific chronic disease states (such as ESRF, IBS, DM, or cancer), recent surgery or trauma, extremes of age, pregnancy or oral contraceptive use.

Signs and symptoms
The majority of CVAD-associated thrombosis events will be clinically silent and will not produce classic signs and symptoms of a DVT. The following list however, outlines the most commonly associated symptoms, which may present in the affected extremity (for PICCs) or the shoulder, neck, chest, and chest wall in proximity to CVAD site.
• Distention or engorgement of the veins surrounding or distal to the CVAD insertion site
• Edema (generalized) or erythema
• Pain or difficulty with motion

Prevention
• Avoiding complications begins with proper device selection and placement. The INS 2016 infusion standards of practice recommend the use of the smallest device, with the fewest lumens, and the least invasive device type required, to be maintained for the shortest duration possible (Gorski et al., 2016). Of equal importance in reducing the risk of DVT, is careful site selection in those with chronic disease states. Sites of the arm are more likely to result in high risk for DVT when compared to sites of the internal jugular or subclavian veins.
• Encourage patients to employ nonpharmacologic strategies to prevent venous thrombosis whenever possible. This includes early mobilization of extremities with CVADs, normal performance of appropriate ADLs, gentle limb exercise, and maintaining adequate hydration.

Management
• The INS standards clearly state that a well-placed and functioning CVAD, with no sign of infection should not be removed simply because there is a DVT at the insertion site or along its course (Gorski et al., 2016). This is because the removal and replacement of the CVAD is likely to precipitate the same response at the next insertion site.
• When DVT presence is confirmed with ultrasound, treatment of the DVT should be initiated by the LIP.
Reference: