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 (cancer, renal failure), and emergency care. CVADs include central venous catheters, implanted ports, hemodialysis catheters, umbilical catheters, central apheresis catheters, and peripherally inserted central catheters (PICC). CVADs provide numerous advantages over peripheral intravenous (IV) access, but the increased risk of infection, thrombosis, and catheter malfunction require specialized care and precautions.

Complications of CVADs can increase hospital length of stay and health care costs and can negatively affect quality of life. 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) 2024 *Infusion Therapy Standards of Practice* recommends 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 (Nickel et al., 2024). The provider, nurse, and patient will decide together which type of CVAD best meets the treatment needs while considering lifestyle factors. Using standard precautions and 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 IV fluid or non-vesicant 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

- Misplaced access of a CVAD (an implanted subcutaneous port, for example)
- Fractured/damaged device below the skin
- Dislodgement of a CVAD through patient movement
- Improper device placement

Signs and symptoms

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

**Additional signs of extravasation from a CVAD may be as subtle as edema or a raised area near the insertion site. Extravasation 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 before and during flushing and/or administration of medications through a CVAD includes observation, palpation, checking for blood return, and ease of flushing. Any patient report of pain at the site or with injection should prompt further evaluation.

**Blood return should be present from all lumens of the device. Further evaluation and intervention are recommended if any or all the lumens do not provide blood return.*

Management

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

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 catheter 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 lumen or sluggish blood return
- Sluggish flow or frequent occlusion/high pressure alarms on electronic infusion devices
- Inability to flush or infuse through a CVAD
- Swelling or leaking at the insertion site

Prevention

- Use proper facility-approved flushing and locking protocols.
- When flushing the lumen(s) with saline, use a pulsatile technique.
- Check for incompatibilities when infusing two or more drugs together.
- Identify drugs at high risk for causing precipitate in tubing/devices.
- Use a catheter securement device to prevent catheter dislodgement.
- 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. Notify the provider as the catheter may have migrated.

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 following insertion
- Respiratory difficulty after insertion, due to phrenic nerve disruption (with external jugular, internal jugular, or subclavian lines)
- Unusual presentation of pain or discomfort near insertion site
- Horner's syndrome – an extremely rare complication involving 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 provider/vascular access specialist to create alternate vascular access plan. Assess and treat the nerve injury.

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 end-stage renal disease (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-associated bloodstream infection (CABSI).*

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 the provider to determine ability to salvage CVAD versus replace the CVAD whenever a CABSI is suspected in a long-term access site.
- Alternate vascular access plans should be made in collaboration with the patient care team and patient/family wishes as appropriate.

Air Embolism

Air embolism is a rare but potentially fatal complication 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 vasculature. This phenomenon is associated with central line placement in the subclavian vein and due to changes in intrathoracic pressure related to normal breathing. Air embolism can also occur due to air entering lumens of already placed CVADs.

Signs and symptoms

Have a high degree of suspicion for air embolism in a patient with acute and sudden onset of:

- Dyspnea, gasping, 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
- Sudden drop in end-tidal CO_2 noted on capnography

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 air embolism is a potentially fatal medical emergency; 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's home or other care setting.
- Position the patient in Trendelenburg/left-lateral decubitus, or on left side/head down position, if possible, to trap air in lower portion of right ventricle, preventing air from traveling into the pulmonary vasculature.

- 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)*

- Leaking at the site, or catheter dysfunction
- Infiltration/extravasation
- Air entrainment/air embolism
- 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 (10 ml size syringe barrel).
- Do not push forcibly against resistance.

Management

- Intervene early, collaborating with the patient care team and vascular access specialist.
- Stop all infusions and clamp the catheter lumen. Cover any visibly damaged area with an adhesive dressing to prevent air embolism or bleeding.
- Label the catheter “Do Not Use,” while awaiting intervention.

Thrombosis

A CVAD-associated venous thrombosis refers to a superficial or deep vein thrombosis (DVT) along the path of the CVAD. Risk factors include history of DVT, acute critical illness, presence of genetic coagulation abnormalities, specific chronic disease states (such as end-stage renal disease [ESRD], inflammatory bowel disease [IBD], diabetes mellitus [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 2024 Infusion Therapy 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 (Nickel et al., 2024). 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 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 (Nickel et al., 2024). 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 provider.

Catheter-Associated Skin Injury

Catheter-associated skin injury (CASI) refers to an abnormality around the CVAD dressing or securement device that is observable for 30 minutes or more after dressing or securement device removal. This can include erythema, vesicles, bullae, erosion, or tears.

Signs and symptoms

- Discomfort, such as pain and/or pruritus

Prevention

- Avoid insertion into areas of preexisting injury.
- Clip or trim hair at insertion site; don't shave.
- Use alcohol-based chlorhexidine solution as the preferred antiseptic agent; use chlorhexidine gluconate (CHG)-containing dressings, unless contraindicated.
- Use an alcohol-free skin barrier product that is compatible with the antiseptic solution.
- Use the most appropriate dressing and securement device.

Management

- Change the dressing promptly if soiled, not intact, or upon first signs or symptoms of skin impairment.
- Avoid subsequent exposure to products suspected of causing CASI.
- Use strategies to promote skin regeneration and protection.
- Consult with dermatology or wound care as needed.

References:

Nickel, B., Gorski, L., Kleidon, T., Kyes, A., DeVries, M., Keogh, S., Meyer, B., Sarver, M. J., Crickman, R., Ong, J., Clare, S., & Hagle, M. E. (2024). Infusion Therapy Standards of Practice, 9th Edition. *Journal of infusion nursing: the official publication of the Infusion Nurses Society*, *47*(1S Suppl 1), S1–S285. https://doi.org/10.1097/NAN.0000000000000532

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