Recognizing, preventing, and troubleshooting central-line complications

Central lines can be life-saving, but adverse events can jeopardize patient well-being.

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To promote positive outcomes, clinicians caring for patients with central lines must monitor carefully for signs and symptoms of complications. This article discusses potential complications—catheter occlusion, bleeding and hematoma, catheter-tip migration, catheter rupture, phlebitis and associated pain, swelling and deep vein thrombosis (DVT), infection, and embolism. It also provides assessment, prevention, and troubleshooting tips for central lines.

Catheter occlusions

A catheter occlusion occurs when a blockage prevents caregivers from flushing the central line or aspirating blood. An occlusion can be thrombotic or nonthrombotic (not caused by a thrombus). About 40% to 50% of occlusions are nonthrombotic and result from mechanical or postural factors, medication precipitate, catheter malpositioning, or undesirable catheter-tip location.

If you suspect your patient's catheter is occluded, assess the entire infusion-delivery system for obstructions and kinks. Determine if blood return is hampered by the position of the patient's arm or other body part (when either lying or standing). Evaluate the patient's medication profile for drug incompatibilities. Next, assess catheter patency: Does the catheter flush easily, or only with difficulty? Do you see a blood return? Finally, have a qualified clinician assess catheter-tip location from a recent X-ray, if available.

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Learning Objectives

1. Describe at least five complications associated with central lines, along with their causes.
2. Discuss management of central-line complications.
3. Explain how to troubleshoot central-line patency problems.

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Mechanical occlusions

A mechanical occlusion can be external or internal. *External* occlusions stem from a kink or clamp in the portion of the catheter that's outside the patient. Check whether any clamps are activated, and look for sutures or a securement device that could be pinching the catheter too tightly. Then check for kinks in the catheter. Finally, examine the I.V. tubing and pump for obstructions and malfunctions.

Internal occlusions occur inside the patient and are harder to assess. Causes include lodging of the catheter tip against a vessel. If you suspect an internal occlusion, consult the ordering physician or li-

Treating medication-precipitate occlusions

This table shows treatments for nonhemolytic catheter occlusions according to the precipitate used, along with the recommended I.V. fluid to declot the occlusion. Infuse only enough of the ordered fluid to fill the catheter, not for infusion into the bloodstream.

Precipitate	Treatment (requires physician order)
Fat or lipid products	70% ethanol I.V.
Mineral	0.1-N hydrochloric acid I.V.
Acidic medications (pH below 5)	0.1-N hydrochloric acid I.V.
Base medications (pH above 9)	Sodium bicarbonate or 0.1-N sodium hydroxide I.V.

censed independent practitioner, who will weigh the risks and benefits of keeping the catheter in place vs. replacing it.

Another cause of internal catheter occlusion is pinch-off syndrome, in which the catheter passes through the areolar tissue of the space outside the vessel lumen and becomes compressed between the clavicle and rib. As the patient raises and lowers the shoulder, repeated compression and shearing forces put pressure on the catheter. A more lateral catheter insertion allows the catheter to travel within the subclavian vessel. Pinch-off syndrome is a serious complication requiring immediate attention. It may occur with acute, tunneled, and implanted lines placed via the subclavian vein. It doesn't occur with peripherally inserted central catheters (PICCs) because they're inserted in the arm and approach the superior vena cava from inside the vessel.

Postural occlusions

A postural occlusion affects catheter patency or blood flow, depending on patient or catheter position. To find out if patient positioning is affecting blood return, instruct the patient to change positions by raising and lowering the arm, or to take a deep breath or cough. If a position change helps obtain a blood return, consult with the physician on the risks and benefits of leaving the catheter in place vs. removing it.

Medication-precipitate occlusions

If the I.V. bag contains multiple medications, such as potassium, incompatibility may occur in the tubing, causing precipitation. Infusion of parenteral nutrition, lipids, phenytoin, aminophylline, or potassium gluconate with other medications promotes precipitate occlusions. The precipitate forms quickly, causing the line to become sluggish and hard to flush.

If you suspect a catheter occlusion caused by precipitate, review the patient's medical record for possible drug incompatibilities. Consult the pharmacist, who may recommend a fibrinolytic or nonfibrinolytic agent. With a nonfibrinolytic agent, the goal is to increase precipitate solubility by changing the pH in the catheter lumen. For this procedure, first determine the catheter's fill volume. Fill volume varies from PICCs to ports, ranging from 0.3 to 0.5 mL. Larger catheters, such as dialysis catheters, have larger fill volumes; the volume may be marked on the outside of the catheter. Instill the proper amount so the medication contacts the precipitate, not the outside of the catheter. To help prevent medication-precipitate occlusion, flush the catheter between each medication dose. (See *Treating medication-precipitate occlusions.*)

Thrombotic occlusions

Most catheter occlusions are thrombotic, caused by changes in blood flow, venous stasis, hypercoagulability, or trauma to the vessel wall. (See *Types of thrombotic occlusions.*) Thrombosis has been linked to central-line–associated bloodstream infections (CLABSIs), so managing a thrombotic occlusion is crucial to prevent infection. Management entails timely patency assessment and treatment.

If a catheter becomes partially occluded or loses its blood return, a fibrinolytic typically is ordered, to be given according to manufacturer's guidelines. Currently, alteplase is the only fibrinolytic approved by the Food and Drug Administration (FDA) to treat thrombotic occlusions.

Bleeding and hematomas

Expect minimal bleeding after catheter insertion. However, know that certain catheter types, insertion techniques, and laboratory values can make patients more prone to bleeding. When assisting with catheter insertion, control bleeding at the site before the final dressing is applied. If the insertion site continues to bleed or ooze blood, apply a sterile 2" x 2" gauze dressing under the transparent dressing; change the dressing every 24 to 48 hours. Follow your facility's policy on caring for and maintaining a gauze dressing.

If bleeding persists, consider using a pressure dressing or wrap. If your patient with a PICC has a wrap applied around the arm, monitor extremities for color, motion, and sensation according to facility policy. Document the time the pressure wrap was applied and the time it was removed. Sensation loss and numbness have occurred when pressure dressings were applied for more than 24 hours and the site, skin color, motion, and sensation weren't checked.

If bleeding persists beyond 24 to 48 hours after catheter insertion, assess for other possible causes. Determine if bleeding could stem from

Types of thrombotic occlusions

Four types of thrombotic occlusions can occur—intraluminal, mural, fibrin sheath, and fibrin tail.

Intraluminal thrombi account for 5% to 25% of thrombotic occlusions. They form within the central line and can be partial or complete. Left untreated, a partial thrombus may progress to a complete thrombus. Poor flushing technique after blood withdrawal promotes this type of thrombus.

Mural thrombi result from vessel trauma or previous vessel injury. Fibrin from the vessel-wall injury binds to cover the catheter surface. Frequent cannulation attempts and rigid catheters increase the risk of a mural thrombus.

A ***fibrin sheath*** occurs in up to 47% of patients with central lines. It forms when a fibrin layer adheres to the catheter's external surface. Unless treated, it can progress to cause catheter malfunction or a mural thrombus.

A ***fibrin tail*** forms when the catheter tip moves against the wall of the vein and fibrin adheres to the end of the catheter. The tail acts as a one-way valve, allowing fluid infusion but preventing blood aspiration. It can progress to a total occlusion unless treated.

anticoagulant therapy, vigorous physical activity, sutures, or coagulopathy. Be aware that patients with an elevated International Normalized Ratio or sutures that were accidentally placed through small vessels may continue to bleed, as small pinholes within the catheter can cause oozing.

Continue to apply and change sterile gauze dressings every 24 to 48 hours; to promote hemostasis, consider using such agents as an absorbable gelatin sponge at the insertion site. Suture removal or catheter removal or replacement may be warranted to correct the problem. Be sure to monitor the insertion site frequently and document findings.

Catheter-tip migration

If the catheter loses its blood return, suspect catheter-tip migration. The tip may migrate out of the superior vena cava at any time due to catheter- or patient-related factors. Some catheters are made of stiffer materials (such as the nontunneled dialysis catheter), whereas PICCs are more flexible and more likely to migrate. Power injection, power flushing, push-pause flushing methods, vomiting episodes, and suctioning also can cause the catheter tip to migrate in and out of the superior vena cava.

Signs and symptoms of catheter-tip migration include changes in catheter patency or loss of blood return; discomfort in the upper arm, shoulder, jaw, chest, or ear during infusions; and an external catheter length that differs from the length at the time of insertion. For example, if the external length of a PICC was 1 cm at insertion but is now 20 cm, assume the PICC is no longer in the superior vena cava. This also can happen with a central line in the chest: If the line was inserted in the subclavian vessel with 1 cm exposed externally but 3 cm are exposed on day 5, suspect it's no longer lodged in the vessel. (See *Assessing for catheter malposition*.)

Catheter rupture

Pressure generated during catheter flushing can't be measured accurately. A small syringe size (less than 3 mL) may cause higher pressures within the catheter. With partial or complete occlusions, higher pressures occur within the catheter. Excessive pressure on the syringe plunger also can cause unmanageable pressure within the catheter, leading to rupture.

If you encounter resistance when flushing the catheter, stop flushing and try to determine the cause. Don't keep flushing against resistance, as this may lead to catheter embolus or leakage.

If the catheter breaks during flushing, the healthcare team must consider whether to repair or replace it. Points to consider include the following:

- How much longer will central-line therapy continue? Catheter repair may be more appropriate if therapy will continue for a few days, whereas replacement is more appropriate for longer-term therapy.
- Are vessels available for a new insertion? Did the inserting clinician note that the catheter was inserted with much difficulty? Does the patient have a history of multiple catheter insertions?
- Is the catheter appropriate for exchange? Is there a chance of contamination or infection with this catheter or insertion site?
- Is repair feasible based on variables of catheter damage and exposure? What are the possible risks of contamination and infection?
- What are the manufacturer's recommendations? Many catheters don't come with repair kits. Depending on leakage or breakage location, repair may be impossible—for instance, with a double-lumen catheter that's leaking below the bifurcation.
- If the catheter is visibly ruptured on the outside, is there a possibility it has ruptured on the inside? This can be determined only by X-ray or dye study.

If catheter repair is appropriate and a healthcare provider writes an order for it, an infusion or vascular expert should repair it following the manufacturer's guidelines and using aseptic technique, with modification equipment supplied by the manufacturer.

Phlebitis and related pain

Another complication of a central line is phlebitis (vein inflammation) with related pain. Although most common with a PICC, it can occur with any central line. Phlebitis causes erythema, pain, or swelling along the path of the vein in which

Assessing for catheter malposition

Although not done routinely, taking daily external measurements of a central line in a patient's chest can help you assess for catheter malpositioning. Here's how:

- Evaluate blood return before and after you administer each dose of I.V. medication, or at least once during your shift if you don't administer medications through the central line. If you don't see a blood return, suspect catheter occlusion or malpositioning.
- Assess how much of the catheter is exposed externally. If more is exposed than you think should be, check to be sure. Review your facility's policies for measuring external catheter length.
- Make sure the catheter is secured by sutures or a securement device.
- Verify periodic X-rays to reconfirm catheter-tip location when the external catheter length changes or when two doses of fibrinolytics fail to declot the catheter.

the catheter is lodged. The condition is classified as chemical, mechanical, or bacterial.

Chemical phlebitis

Chemical phlebitis is an inflammatory response of the vein intima to the infusates or catheter material used for access. (See *Chemical phlebitis effects*.) It's associated with peripheral I.V. lines but may occur with a central line if the catheter tip migrates from its central location in the superior vena cava. Other causes include extended catheter dwell time, administration of irritating medications or solutions, improperly mixed medications, rapidly infused medications or solutions, or particulate matter.

Mechanical phlebitis

Mechanical phlebitis is associated with catheter movement that irritates the vein intima. Early-stage mechanical phlebitis stems from mechanical irritation of the venous endothelium. It usually occurs several inches proximal to the insertion site. Signs and symptoms include tenderness, erythema, and edema. The most common causes of mechanical phlebitis are large-bore catheters and inadequate catheter securement.

Treatment entails application of low-degree heat from a continuous, controlled source. Continue applying heat until all signs and symptoms resolve, which usually occurs within 72 hours after treatment begins. If they don't resolve, discontinue catheter use. The healthcare team should consider an ultrasound study to rule out DVT. (Patients with prior DVT and surgery lasting longer than 1 hour are at increased risk for catheter-related DVT.) If ultrasound reveals DVT, consult the ordering clinician about treatment options, which include anticoagulants given either with the catheter in place or after its removal.

Bacterial phlebitis

Bacterial phlebitis is an inflammation of the vein intima associated with bacterial infection. The least common type of phlebitis, it is more serious because it predisposes the patient to systemic complications. Contributing factors include:

- poor hand hygiene by healthcare providers
- failure to check equipment for compromised integrity
- poor aseptic technique during catheter site or system preparation
- poor cap or hub disinfection before obtaining catheter access
- poor insertion technique
- inadequate or breached dressing
- infrequent site observation and failure to assess adequately for complications
- preexisting patient condition or infection.

Keep in mind that wearing gloves doesn't eliminate the need to wash your hands before and after patient contact. Use a hand sanitizer or wash your hands for 10 to 15 seconds with soap and running water.

Infection

Healthcare-acquired infections (HAIs) are infections that arise 48 hours after admission, within 3 days after discharge, or within 30 days after surgery. The Centers for Medicare & Medicaid Services has identified conditions that can be prevented by prudent and reasonable care, deeming them "never" events; it no longer reimburses for their care. Vascular catheter-associated infections and air embolism are two "never" events.

More than 80% of HAIs are associated with central lines and other devices. The catheter site and hub are the most important sources of bacteria and fungi leading to

Chemical phlebitis effects

This image shows redness on the right subclavian area of the patient's chest. The patient had an implanted port; tubing leading to the port ruptured and then separated from the housing after injection with contrast. The nurse administered a vesicant chemotherapy agent through the port, observing that it flushed well without blood return. The patient said the port didn't always give a blood return and complained of burning in the chest when the vesicant was administered. The vesicant leaked out of the tubing and into the subclavian vein, causing chemical phlebitis.

catheter colonization and resultant CLABSIs. With short-term catheters (those indwelling less than 14 days), the insertion site is the major contamination source. Bacteria on the patient's skin migrate along the external surface of the catheter; bacterial colonization of the surface leads to formation of biofilm, in which microbes are nested in a protective matrix of extracellular bacterial polymer.

With long-term catheters (those indwelling more than 14 days), the major infection source is intraluminal colonization. Organisms may be introduced if the catheter hub goes unscrubbed, if the catheter is manipulated, or if poor flushing technique is used. Organisms migrate from the hub toward the catheter tip and then to the patient. Biofilm develops, with organisms remaining nested in the biofilm or detaching to float freely in and outside the lumen.

Signs and symptoms of infection can be specific or vague. Redness or swelling may occur at the insertion site. Nonspecific indications include fever, chills, and hypotension.

CLABSIs may warrant central-line withdrawal. Treatment depends on the specific organism present, extent of illness, signs and symptoms, catheter type used, duration of anticipated need for venous access, and presence of alternative venous access.

Embolism

An embolism may involve the catheter itself, fibrin, or air entry.

Catheter embolisms

A catheter embolism occurs with catheter rupture and may result from using too much pressure when flushing the line. If the catheter doesn't flush easily, never try to force it. Assess it for mechanical or fibrin occlusions.

Other causes include power-injecting a nonpower-injectable central line. (The FDA has posted guidelines on power injection and events of catheter breakage. Visit www.fda.gov/MedicalDevices/Safety/AlertsandNotices/TipsandArticlesonDeviceSafety/ucm070193.htm.) Other causes of catheter embolism include migration and catheter breakage from internal and external causes. To prevent these problems, always secure the catheter adequately, avoid pulling or tugging on it, and follow recommendations for its removal when it's no longer needed.

Fibrin embolisms

A fibrin embolism occurs when fibrin breaks off from the catheter during flushing. Signs and symptoms depend on where the clot travels. This type of embolism must be treated immediately, but can be hard to detect due to the resources needed (such as computed tomography and angiography). The best way to prevent a fibrin embolism is to assess the catheter every shift and provide proper care and maintenance.

Air embolisms

An air embolism can arise during catheter insertion, maintenance, or removal. Be sure to minimize air entry during insertion by positioning the patient and equipment properly. Air can enter the patient accidentally through loose caps and non-Luer Lock—type devices and syringes. When caring for a central line, make sure all air is removed from syringes, all syringes and devices are the Luer Lock type, and all caps are applied securely to the central line.

Air embolism also can occur during central line removal. To decrease this risk, use techniques that prevent air from entering the insertion site after catheter removal. For removal, position the patient flat or in a slight Trendelenburg position to increase intrathoracic pressure. Have the patient hold the breath or breathe out. For a patient on a ventilator, check the manufacturer's guidelines on whether to remove the catheter on inspiration or expiration. Many of the new ventilator settings provide pressure on expiration for catheter removal.

Applying a dressing on the catheter insertion or exit site also helps prevent air embolism. On catheter removal, apply an occlusive dressing to seal the site; this prevents small amounts of air from tracking down the insertion site to the vessel. An occlusive dressing includes an antiseptic ointment or petrolatum gauze placed under a gauze dressing. (Gauze dressings by themselves aren't occlusive.) Some clinicians place a transparent dressing atop the gauze dressing. However, be aware that transparent dressings are semipermeable and breathable—not occlusive. Finally, keep the patient flat in bed for 30 minutes after catheter removal and monitor for signs and symptoms of embolism: shortness of breath; chest pain; cough; wheezing; skin that's cool, clammy, or bluish; rapid or irregular heartbeat; weak pulse; and lightheadedness or fainting. If these occur, turn the patient onto the left side, call the rapid response team (if available at your facility), apply oxygen, notify the physician, and start basic life support if necessary.

Toward better outcomes

With the basic information in this article, you can help prevent, recognize, and troubleshoot central-line complications. Also be sure to consult your facility's policy and procedures; all healthcare facilities should use current guidelines recommended by national organizations, research, and evidence-based practice. Your expanded knowledge base and use of evidence-based policy and procedures can help you optimize patient outcomes. ✭

Visit www.AmericanNurseToday.com/Archives.aspx for a list of selected references and an algorithm for troubleshooting central lines.

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Purpose/goal

To provide nurses with information on complications of central lines, including their causes, management, and prevention.

Learning Objectives

1. Describe at least five complications associated with central lines, along with their causes.
2. Discuss management of central-line complications.
3. Explain how to troubleshoot central-line patency problems.

Please mark the correct answer online.

1. The blood return on your patient's central line decreases when he lies down. You find no kinks in the tubing. What's the most likely cause of this problem?

a. Catheter rupture
b. Hematoma
c. Medication-precipitate occlusion
d. Catheter occlusion

2. Which of the following complications is most likely to cause a central line to become sluggish?

a. Catheter rupture
b. Hematoma
c. Medication-precipitate occlusion
d. Catheter occlusion

3. The site of your patient's central line is oozing blood. What is an appropriate action to take?

a. Apply a sterile gauze dressing under a transparent dressing.
b. Apply a transparent dressing under a sterile gauze dressing.
c. Change the dressing every 12 hours.
d. Change the dressing every 72 hours.

4. Which statement about catheter migration is correct?

a. Peripherally inserted central catheters (PICCs) are more flexible than other central catheters and are more likely to migrate.
b. PICCs are less flexible than other central catheters and are less likely to migrate.
c. PICCs are more flexible than other central catheters and are less likely to migrate.
d. PICCs are less flexible than other central catheters and are more likely to migrate.

5. Your patient states she has jaw and ear discomfort during infusions of antibiotics. Her symptoms may indicate:

a. thrombotic occlusion.
b. mechanical phlebitis.
c. catheter-tip migration.
d. catheter rupture.

6. A possible cause of chemical phlebitis is:

a. short catheter dwell time.
b. extended catheter dwell time.
c. slowly infused medications.
d. catheter tip in the superior vena cava.

7. Which statement about mechanical phlebitis is correct?

a. Signs and symptoms usually resolve less than 24 hours after treatment begins.
b. Signs and symptoms usually resolve about 1 week after treatment begins.
c. Mechanical phlebitis is treated by application of low-degree heat.
d. Mechanical phlebitis is treated by application of high-degree heat.

8. Your patient develops an infection 3 weeks after a central line was placed. What is the most likely source of the infection?

a. External catheter colonization
b. Microbes in an intracellular bacterial polymer
c. Insertion-site infection
d. Intraluminal colonization

9. To prevent an air embolism, what action should you take during removal of a central line?

a. Ask the patient to hold his or her breath.
b. Ask the patient to breathe in.
c. Place the patient in an upright position.
d. Place the patient in a reverse Trendelenburg position.

10. Which of the following should you do after removal of a patient's central line?

a. Apply a gauze dressing and a transparent dressing.
b. Apply an antiseptic ointment or petrolatum gauze under a gauze dressing.
c. Keep the patient flat for 1 hour.
d. Keep the patient flat for 15 minutes.

11. Which type of thrombotic occlusion occurs in up to 47% of patients with central lines?

a. Intraluminal thrombus
b. Mural thrombus
c. Fibrin sheath
d. Fibrin tail

12. Which type of thrombotic occlusion occurs when the catheter tip moves against the wall of the vein and fibrin adheres to the end of the catheter?

a. Intraluminal thrombus
b. Mural thrombus
c. Fibrin sheath
d. Fibrin tail

13. Which statement about how to assess for catheter malposition is *not* correct?

a. Assess how much of the catheter is exposed externally.
b. Evaluate blood return every 48 hours.
c. Make sure the catheter is secured by sutures or a securement device.
d. Verify periodic X-rays to reconfirm catheter-tip location.

14. What is an appropriate treatment for precipitate from fat or lipid products?

a. 70% ethanol I.V.
b. 0.1-N hydrochloric acid I.V.
c. Sodium bicarbonate
d. 0.5-N sodium hydroxide I.V.

15. You suspect a nonthrombotic occlusion in your patient's central line, but you find no problem with the equipment. An appropriate next step is to:

a. mix Cathflo and instill into the catheter; repeat in 1 hour.
b. assess the catheter length outside the body and compare it with baseline.
c. discuss removal of the catheter with the patient's physician.
d. obtain an order for a dye study to assess further.

16. What is an appropriate treatment for a thrombotic occlusion?

a. Sodium bicarbonate
b. 70% ethanol
c. Alteplase
d. Corticosteroid

Central-line problems: Troubleshooting flowchart

Use this algorithm to guide assessment and management of central-line occlusions.