Infusion Therapy Standards of Practice

Barbara Nickel, APRN-CNS, CCRN, CRNI®
Lisa Gorski, MS, RN, HHCNS-BC, CRNI®, FAAN
Tricia Kleidon, PhD(c), MNSc, RN
Amy Kyes, MSN, APRN, AG-CNS, CV-BC™, CRNI®
Michelle DeVries, MPH, CIC, VA-BC, CPHQ, FAPIC
Samantha Keogh, PhD, RN, FACN
Britt Meyer, PhD, RN, CRNI®, VA-BC, NE-BC
Mary Jo Sarver, MSN, ARNP, AOCN, CRNI®, LNC, VA-BC
Rachael Crickman, DNP, ARNP-CNS, AOCNS, OCN, RN
Jenny Ong, PharmD
Simon Clare, MRes, BA, RGN
Mary E. Hagle, PhD, RN-RB, FAAN

9TH EDITION

REVISED 2024

INFUSION NURSES SOCIETY
SETTING THE STANDARD FOR INFUSION CARE®

One Edgewater Drive, Norwood, MA 02062
www.ins1.org

peripherally infused amiodarone: a randomized clinical trial. *J Vasc Nurs*. 2017;35(1):31-35. doi:10.1016/j.jvn.2016.11.001

24. Harris DL, Schlegel M, Markovitz A, Woods L, Miles T. Securing peripheral intravenous catheters in babies without applying adhesive dressings to the skin: a proof-of-concept study. *BMC Pediatr*. 2022;22(1):1-7. doi:10.1186/s12887-022-03345-8
25. Gorski L. Peripheral IV catheter insertion and management. In: Gorski L, ed. *Phillips' Manual of IV therapeutics: Evidence-based Practice for Infusion Therapy*. 8th ed. F.A. Davis; 2023:258-318.
26. Schults JA, Long D, Pearson K, et al. Insertion, management, and complications associated with arterial catheters in paediatric intensive care: a clinical audit. *Aust Crit Care*. 2020;33(4):326-332. doi:10.1016/j.aucc.2019.05.003
27. Bilal S. Question 1: Does use of a splint increase the functional duration of cannulae in neonates? *Arch Dis Child Educ Pract Ed*. 2014;99(7):694. doi:10.1136/archdischild-2013-305928
28. Akl KF. Misuse of the wooden tongue depressor. *Indian J Pediatr*. 2010;77(5):579. doi:10.1007/s12098-010-0026-0

38. FLUSHING AND LOCKING

Standard

38.1 Vascular access devices (VADs) should be assessed for patency (ie, flushed and aspirated for a blood return) prior to each infusion to assess catheter function and prevent complications.

38.2 VADs are flushed after each medication administration with sufficient volume and appropriate rate to complete the medication administration and to reduce the risk of contact between incompatible medications.

38.3 Each VAD lumen is locked after completion of the final flush and infusion ceased to decrease the risk of intraluminal occlusion and/or to reduce catheter-associated bloodstream infection (CABSI) risk, depending on the solution used.

38.4 Standardized protocols for flushing and locking solutions are established within each organization.

Practice Recommendations

A. Use single-dose systems (eg, single-dose vials and syringes or prefilled labeled syringes) for all VAD flushing and locking.[1,2] (V)
   1. A syringe or needle should be considered contaminated once it has been used to enter or connect to a patient's intravenous (IV) solution container or administration set.[1] (V)
   2. Use commercially manufactured prefilled flush syringes (when available) to reduce the risk of catheter-associated bloodstream infection (CABSI) and device failure, save time for syringe preparation, and aid optimal flushing technique and objectives.[3-8] (II)
   3. Do not use IV solution containers (eg, bags or bottles) as a source for obtaining flush solutions (see Standard 56, *Compounding and Preparation of Parenteral Solutions and Medications*).[2,9] (IV)
   4. Use new, unopened, single-use, commercially available prefilled syringes for flushing before and after medications. Using the same prefilled syringe to flush a VAD before and after the medications can potentially contaminate the prefilled syringe tip and thereby transfer the contamination to the VAD.[2,9,10] (IV)
   5. If a patient reports disturbance in taste and odor/smell, inform them that prefilled flush syringes are occasionally associated with this and that it has been found to be more prominent when flushing central venous access devices (CVADs) than with peripheral intravenous catheters (PIVCs). The cause is thought to be substances leaching from the plastic syringe due to sterilization methods. These sensations may be significant enough to impact appetite and may increase nausea, especially if administered rapidly. This sensation can be minimized with a slower injection rate. Reassure patient that sensation will subside when injection/flush has ceased.[11] (III)

B. Disinfect connection surfaces (ie, needleless connectors, injection ports) before flushing and locking procedures (refer to Standard 34, *Needleless Connectors*).

C. Flush all VADs with preservative-free 0.9% sodium chloride.[12] (V)
   1. Use a minimum volume equal to twice the internal volume of the catheter system (eg, catheter plus add-on devices). Larger volumes (eg, 5 mL for PIVC, 10 mL for CVADs) may remove more fibrin deposits, drug precipitate, and other debris from the lumen. Factors to consider when choosing the flush volume include the type and size of catheter, age and weight of the patient, and type of infusion therapy being given. Blood sampling or infusion of blood components, parenteral nutrition (PN), contrast media, and other viscous solutions may require larger flush volumes.[13-16] (V)
   2. If bacteriostatic 0.9% sodium chloride is used, limit flush volume to no more than 30 mL in a 24-hour period to reduce the possible toxic effects of the preservative, benzyl alcohol.[12] (V)
   3. Use only preservative-free solutions for flushing all VADs in neonates and infants to prevent toxicity.[12] (V)
   4. Use 5% dextrose in water followed by preservative-free 0.9% sodium chloride when the medication is incompatible with sodium chloride. Do not allow dextrose to reside in the catheter lumen, as it provides nutrients for biofilm growth.[2,9] (IV)
   5. Never use sterile water for flushing VADs.[17] (V)

D. Assess VAD function using a 10-mL syringe or a syringe specifically designed to generate lower injection pressure (ie, 10-mL diameter syringe barrel), taking note of any resistance.[13,15,16] (V)
   1. Use a single-use prefilled 0.9% sodium chloride syringe to slowly aspirate the VAD for free-flowing blood return that is the color and consistency of whole blood, an important component of assessing catheter function during the initial flush and prior to administration of medications and solutions (see Standard 46, *Vascular Access Device Occlusion*;

Standard 51*, Central Vascular Access Device Malposition*).[9,10] (IV)

a. When blood return is sluggish/absent or assessment of blood return is contraindicated due to the patient's condition (eg, hemodynamic instability dependent on vasopressor delivery), VAD patency should be evaluated through alternative signs, including ongoing clinical response to an infusing medication, lack of resistance to flushing, site evaluation, and patient symptom report. This assessment can assist in determining patency.
    i. For a peripheral VAD (eg, short/long PIVC, midline) that no longer has a positive blood return, increase the frequency of assessment of the insertion site and the venous pathway of the VAD to minimize the risk and severity of complications, such as infiltration, extravasation, and occlusion. If using the PIVC for vesicant administration, plan to transition the infusion to a new VAD when clinically possible. Peripheral administration of certain antineoplastic vesicants is contraindicated in the absence of blood return (refer to Standard 58, *Antineoplastic Therapy*).
    ii. In situations with increased line/luminal volume and high-risk medications (eg, vasopressors, inotropes), aspirating for blood return might be contraindicated in patients where interruptions of the infusion or inadvertent bolus could cause a clinically relevant decline in the patient's condition. In these patients, blood return could be evaluated when the infusion is paused for other reasons (eg, bag change, blood draw, tubing change). Increase the frequency of assessment of the insertion site and clinical response to the medications. Promptly evaluate and treat CVAD occlusion (refer to Standard 44, *Infiltration and Extravasation;* Standard 46, *Vascular Access Device Occlusion*; Standard 65, *Vasopressor Administration*). (Committee Consensus)

2. Do not forcibly flush any VAD with any syringe size. If resistance is met and/or no blood return noted, take further steps (eg, checking for closed clamps or kinked sets, removing dressing, conducting a thorough patient and site assessment) to locate an external cause of the obstruction. Internal causes may require diagnostic tests, including, but not limited to, a chest radiograph to confirm tip location and mechanical causes (eg, pinch-off syndrome), color duplex ultrasound, or fluoroscopy to identify thrombotic causes (see Standard 50, *Catheter-Associated Thrombosis*; Standard 51, *Central Vascular Access Device Malposition*).[13,14,18] (V)
3. After confirming catheter patency, use an appropriately sized syringe for medication dose. Do not transfer the medication to a larger syringe (see Standard 56, *Compounding and Preparation of Parenteral Solutions and Medications*).[2] (V)
4. Do not use prefilled flush syringes for dilution of medications. Differences in gradation markings, an unchangeable label on prefilled syringes, partial loss of the drug dose, and possible contamination increase the risk of serious medication errors with syringe-to-syringe drug transfer (see Standard 56, *Compounding and Preparation of Parenteral Solutions and Medications*).[2] (V)

E. Flush the VAD lumen with preservative-free 0.9% sodium chloride following the administration of an IV push medication at the same rate of injection as the medication. Use an amount of flush solution to adequately clear the medication from the lumen of the administration set and VAD.[2,9,13,15,16] (V)

F. Use positive-pressure techniques to minimize blood reflux into the VAD lumen.[13,15,16,18,19] (I)
1. Prevent syringe-induced blood reflux by leaving a small amount (eg, 0.5 mL to 1.0 mL) of flush solution in a traditional syringe (ie, one without a positive pressure plunger) to avoid compression of the plunger rod gasket and prevent this type of reflux.[13,15,16,18,19] (V)
2. Prevent connection/disconnection reflux by using the appropriate sequence for flushing, clamping, and disconnecting determined by the type of needleless connector being used (refer to Standard 34, *Needleless Connectors*).
3. Use a gentle pulsatile flushing technique to deliver flush into the catheter.
    a. In vitro studies have shown that intermittent, pulsatile (eg, 10 short boluses of 1-mL solution interrupted by brief pauses) may be more effective at removing solid deposits (eg, fibrin, drug precipitate, intraluminal bacteria) compared to continuous low-flow techniques.[20,21] (IV)
    b. The Centers for Disease Control and Prevention (CDC) recommends flushing CVADs vigorously using pulsating technique.[22] (V)
    c. Other computational, in vitro, and animal studies have demonstrated that the vessel endothelium is vulnerable to damage with repeated, high-pressure injection, and blood components are vulnerable to clotting through stasis at the catheter tip.[18,23-25] (IV)
    d. A further laboratory study and small clinical trial demonstrated no significant differences in device clearance or occlusion rates between continuous or pulsatile flush techniques, suggesting that either method is acceptable.[26,27] (III)
    e. Larger clinical trials are needed to provide more clarity on the most appropriate flush technique

contextualized to the population and situation. Consequently, the current recommendation is to use a gentle, pulsatile flush technique to balance the need to maintain catheter patency, reduce the risk of mixing incompatible medications/fluids, and optimize vessel health and preservation. (Committee Consensus)

4. Consider flushing all lumens of a multilumen catheter after obtaining blood samples to reduce the possibility of changing intraluminal pressure causing blood reflux into the other lumens. (Committee Consensus)
5. Follow manufacturers' directions for use regarding clamping the VAD when not in use. Clamping can prevent contamination and exsanguination in the event of inadvertent disconnection of any set or add-on device, per manufacturer instructions for use (IFU) (refer to Standard 34, *Needleless Connectors*).

G. Lock short and long PIVCs and midline catheters immediately following each use.
   1. In adults, use preservative-free 0.9% sodium chloride for locking.[28,29] (II)
   2. In neonates and pediatric patients, use preservative-free 0.9% sodium chloride or heparin 0.5 to 10 units/mL. Outcome data in these patient populations are inconclusive.[19] (II)
      a. In one prospective trial, intermittent flushing with 0.9% sodium chloride was associated with a lower rate of complication and similar duration of patency when compared to continuous infusion in PIVCs placed in newborns.[30] (IV)
   3. For PIVCs and midline catheters not being used for intermittent infusion or medication administration, remove as soon as no longer required; but if they must be maintained, assess, flush, and relock at least once every 24 hours using a volume reflective of the device and any add-on devices, as per minimum flush calculation stated prior and with a 10-mL syringe or syringe with same barrel size as a 10-mL syringe (see Standard 42, *Vascular Access Device Removal*).[14,31] (III)

H. Lock CVADs with either preservative-free 0.9% sodium chloride or heparin according to the provider order for the VAD and needleless connector.[13,15,18,32,33] (I)
   1. In adults, randomized controlled trials (RCTs) and systematic reviews have shown equivalent outcomes with heparin and sodium chloride lock solutions for multilumen, nontunneled CVADs, peripherally inserted central catheters (PICCs), and implanted vascular access ports while accessed and when the access needle is removed.[15,16,18,32,34] (I)
   2. Use heparin or preservative-free 0.9% sodium chloride for locking CVADs in children. There is insufficient evidence regarding the best antithrombotic lock solution in CVADs in children.[35] (II)
   3. The volume of the lock solution should equal the internal volume of the VAD and add-on devices plus 20% (10% in infants/neonates). Flow characteristics during injection will cause overspill into the bloodstream. Lock solution density is less than whole blood, allowing leakage of lock solution and ingress of blood into the catheter lumen when the CVAD tip location is higher than the insertion site. Careful monitoring of patient and device response is required.[13] (V)
   4. There is insufficient evidence to recommend the optimal frequency, solution, volume, or technique to maintain the patency of implanted vascular access ports not accessed for infusion.[36] (II)
      a. Use at least 10 mL of 0.9% sodium chloride (adult).
      b. Use of 0.9% sodium chloride alone may be as effective as heparin in maintaining patency (see Standard 26, Implanted Vascular Access Ports).[37] (III)
      c. Extending maintenance flushing to every 3 months with 10 mL of 0.9% sodium chloride and 3 or 5 mL of heparin (100 units/mL) was found to be safe and effective in maintaining patency.[38] (II)
      d. Flush implanted vascular access ports daily when accessed but are without regular medication or a continuous infusion in progress (see Standard 26, *Implanted Vascular Access Ports*).[36,39-41] (V)
      e. In vitro studies demonstrated that flushing with 10-20 mL of 0.9% sodium chloride solution and sequencing parenteral nutrition administration post-intravenous lipid emulsion (ILE) may reduce ILE build up and prolong device dwell time (see Standard 61, *Parenteral Nutrition*).[42] (V)

I. Because of potential conflicts with religious beliefs, inform patients when using heparin derived from animal products (eg, porcine, bovine) and obtain assent. Use preservative-free 0.9% sodium chloride instead of heparin when possible in this patient population.[43] (V)

J. When locking hemodialysis CVADs with citrate or heparin lock solution, low-concentration citrate (<5%) is recommended to reduce the risk of central line-associated blood stream infections (CLABSI) and CVAD dysfunction. Tissue plasminogen activator (tPA) may be used prophylactically once per week to reduce CVAD occlusion. The choice of locking solution is based upon clinician discretion due to inadequate evidence to demonstrate a difference between solutions (refer to Standard 27, *Vascular Access and Hemodialysis*).

K. General recommendations for maintaining patency in CVADs used for apheresis include high-concentration heparin and sodium citrate.
   1. Use heparin and citrate cautiously in some patient populations and monitor patient tolerance closely, as heparin-induced thrombocytopenia (HIT) was identified as a risk in patients with multiple myeloma who required stem cell harvesting for auto transplantation. An unusually high frequency of HIT was

identified (4%) (refer to Standard 29, *Vascular Access and Therapeutic Apheresis*).

L. Use solution containing heparin (eg, 1 unit/mL of heparin) or preservative-free 0.9% sodium chloride as a continuous infusion to maintain patency of arterial catheters used for hemodynamic monitoring. The decision to use preservative-free 0.9% sodium chloride instead of heparin infusion should be based on the clinical risk of catheter occlusion, the anticipated length of time the arterial catheter will be required, and patient factors such as heparin sensitivities.[44] (III)

M. Apply the following recommendations for neonates and pediatric patients:
   1. Use a continuous infusion of heparin 0.5 units/kg for all CVADs in neonates. There is insufficient evidence to support use of intermittent heparin vs 0.9% sodium chloride in long-term CVADs in infants and children.[19,45] (II)
   2. Maintain patency and reduce risk of thrombosis by continuous infusion of heparin 0.25 to 1 unit/mL (total dose of heparin: 25-200 units/kg/d) for umbilical arterial catheters in neonates (refer to Standard 28, *Umbilical Catheters*).

N. Change to an alternative locking solution when the heparin lock solution is thought to be the cause of adverse drug reactions from heparin; when heparin-induced thrombocytopenia and thrombosis (HITT) develops; and when there are spurious laboratory studies drawn from the CVAD that has been locked with heparin. High concentrations of heparin used in hemodialysis catheters could lead to systemic anticoagulation. HIT has been reported with the use of heparin lock solutions, although the prevalence is unknown.[13,15] (IV)

O. Use antimicrobial locking solutions for therapeutic and prophylactic purposes in patients with long-term CVADs in the following circumstances: patients with a history of multiple CABSIs, high-risk patient populations, and in facilities with unacceptably high rates of CLABSI, despite implementation of other methods of infection prevention (see Standard 61, *Parenteral Nutrition*).[15,39,46-53] (II)
   1. There is insufficient evidence to indicate the optimal locking solution for long-term CVADs. Factors associated with increased risk of complication (eg, occlusion, infection, altered catheter integrity) in outpatients with CVADs include devices with more than 1 lumen, female gender, and administration of PN.[15,51] (III)
      a. Antibiotic lock solutions contain supratherapeutic concentrations of antibiotics and may be combined with heparin; however, heparin may stimulate *Staphylococcus aureus* biofilm formation. Anticipate the chosen antibiotic to be based on the specific infecting organism or on prevalent organisms within the organization when prophylaxis is the indication. For therapeutic use, start the antibiotic lock solutions within 48 to 72 hours of diagnosis; however, the optimal duration of use is not established.[15,39,46-48,52] (II)
      b. Antiseptic locking solutions include solutions used alone or in numerous combinations, including, but not limited to, ethanol, sodium bicarbonate, taurolidine, citrate, concentrated sodium chloride, and ethylenediaminetetraacetic acid (EDTA).[15,49-51,53-56] (II)
   2. Consult with pharmacy to assure that combination lock solutions are physically compatible, chemically stable, and produce the desired antimicrobial effect. (Committee Consensus)
   3. Consider and evaluate compatibility of the catheter material with the lock solution.
      a. While ethanol lock solution has been proven to be effective in eliminating bacterial growth within biofilm, it has also been associated with negative outcomes: altered catheter integrity, systemic symptoms, and plasma precipitation with potential for catheter occlusion. The impact on catheter integrity is related to the concentration of ethanol lock solution used and the duration of exposure to the catheter inner lumen.[15] (II)
   4. Monitor patients treated with sodium citrate (an anticoagulant with antimicrobial effects) for systemic anticoagulation, hypocalcemia that could produce cardiac arrest, and protein precipitate formation with concentrations greater than 12%.[15,46,49-51] (III)
      a. Monitor trisodium citrate for protein precipitation, which could cause lumen occlusion.[15] (V)
   5. The length of time that antimicrobial lock solutions should reside inside the CVAD lumen is inconclusive; up to 12 hours per day may be required, thus limiting use in patients receiving continuous or frequent intermittent infusions.[15,57] (IV)
   6. Aspirate all antimicrobial locking solutions from the CVAD lumen at the end of the locking period. Do not flush the lock solution into the patient's bloodstream, as this could increase development of antibiotic resistance and other adverse effects. Gentamicin-resistant bacteria from gentamicin lock solution have been reported to increase CABSI rates.[15,49] (V)

REFERENCES

Note: All electronic references in this section were accessed between October 14, 2022, and August 31, 2023.

1. Centers for Disease Control and Prevention. One & only campaign. (https://www.cdc.gov/injectionsafety/one-and-only.html)
2. Institute for Safe Medication Practices. ISMP safe practice guidelines for adult IV push medications: a compilation of safe practices from the ISMP Adult IV Push Medication Safety Summit. Institute for Safe Medication Practices, 2015. https://www.ismp.org/sites/default/files/attachments/2017-11/ISMP97-Guidelines-071415-3.%20FINAL.pdf
3. Bertoglio S, Rezzo R, Merlo FD, et al. Pre-filled normal saline syringes to reduce totally implantable venous access device-associated

34. Millington SJ, Lalu MM, Boivin M, Koenig S. Better with ultrasound: subclavian central venous catheter insertion. *Chest*. 2019;155(5):1041-1048. doi:10.1016/j.chest.2018.12.007
35. Wang J, Liu F, Liu S, Wang N. An uncommon cause of contralateral brachial plexus injury following jugular venous cannulation. *Am J Case Rep.* 2018;19:289-291. doi:10.12659/AJCR.908125
36. Bardin-Spencer A. Ultrasound-guided peripheral arterial catheter insertion by qualified vascular access specialists or other applicable health care clinicians. *J Assoc Vasc Access*. 2020;25(1):48-50. doi:10.2309/j.java.2019.003.008
37. Braverman J. Bedside ultrasound for procedural assistance in pediatrics. *Pediatr Ann*. 2021;50(10):e404-e410. doi:10.3928/19382359-20210914-01
38. Flumignan RL, Trevisani VF, Lopes RD, Baptista-Silva JC, Flumignan CD, Nakano LC. Ultrasound guidance for arterial (other than femoral) catheterisation in adults. *Cochrane Database Syst Rev*. 2021;10(10):CD013585. doi:10.1002/14651858.CD013585.pub2
39. Raphael CK, El Hage Chehade NA, Khabsa J, Akl EA, Aouad-Maroun M, Kaddoum R. Ultrasound-guided arterial cannulation in the paediatric population. *Cochrane Database Syst Rev*. 2023;3(3):CD011364. doi:10.1002/14651858.CD011364.pub3
40. Coulter K. Successful infusion therapy in older adults. *J Infus Nurs*. 2016;39(6):352-358. doi:10.1097/NAN.0000000000000196
41. Fujii C. Clarification of the characteristics of needle-tip movement during vacuum venipuncture to improve safety. *Vasc Health Risk Manag.* 2013;9(1):381-390. doi:10.2147/VHRM.S47490
42. Blake S, Dean D, Chance EA. Antecubital venipuncture resulting in compartment syndrome of the anterior brachium: a case report. *JBJS Case Connect*. 2013;3(1):e12. doi:10.2106/JBJS.CC.K.00165
43. Janakos M, Haustein D, Panchang P. Musculocutaneous neuropathy due to PICC line insertion: a case report. *PM and R*. 2017;9(9):S202. doi:10.1016/j.pmrj.2017.08.159
44. Seligman C, Woodman K. Proximal median neuropathy with brachial plexitis after PICC placement; a case study and review of neurologic complications associated with central venous catheter placement. *Neurology*. 2019;92(15 Supplement P2.4-013).
45. Pare JR, Moore CL. Intravenous infiltration resulting in compartment syndrome: a systematic review. *J Patient Saf*. 2018;14(2):e6-e8. doi:10.1097/PTS.0000000000000233
46. Kistler JM, Ilyas AM, Thoder JJ. Forearm compartment syndrome: evaluation and management. *Hand Clin*. 2018;34(1):53-60. doi:10.1016/j.hcl.2017.09.006
47. Wilson BG. Contrast media-induced compartment syndrome. *Radiol Technol.* 2011;83(1):63-77.
48. Elahi F, Reddy CG. Venipuncture-induced complex regional pain syndrome: a case report and review of the literature. *Case Rep Med*. 2014;2014:613921. doi:10.1155/2014/613921
49. Pruthi P, Arora P, Mittal M, Nair A, Sultana W. Venipuncture induced complex regional pain syndrome presenting as inflammatory arthritis. *Case Rep Med*. 2016;2016:8081401. doi:10.1155/2016/8081401

46. VASCULAR ACCESS DEVICE OCCLUSION

Standard

46.1 Vascular access device (VAD) patency is routinely assessed and defined by the ability to flush all catheter lumens without resistance after establishing blood return from each lumen.

46.2 Catheter salvage is preferred over catheter removal with the choice of clearing agents based on a thorough assessment of potential causes of occlusion.

46.3 When catheter patency cannot be confirmed and there is continued need for the device, alternative actions are implemented, such as evaluation by an infusion/vascular access specialist team (VAST), radiographic studies to identify catheter tip location or to evaluate catheter flow, and/or pharmacy consult to determine cause of occlusion.

Practice Recommendations

A. Reduce the risk for VAD occlusion.
   1. Use recommended flushing and locking procedures (refer to Standard 38, *Flushing and Locking*).
   2. Prevent catheter dislodgement (partial or complete) through appropriate catheter securement (refer to Standard 36, *Vascular Access Device Securement*; Standard 51, *Central Vascular Access Device Malposition*).
   3. Avoid incompatible mixing of intravenous (IV) solutions and/or medications.
      a. Check for incompatibility when 2 or more drugs/solutions are infused together (eg, combined in same container, administered as an intermittent solution for a short-term infusion or a manual injection, or administered concomitantly through the same VAD). Consult with a pharmacist or use an evidence-based compatibility reference when unsure of compatibility; if no compatibility information is found, consider the mixture as incompatible.[1-5] (IV)
      b. Identify medications/solutions at high risk for precipitation. These may include alkaline drugs such as phenytoin, diazepam, ganciclovir, acyclovir, ampicillin, imipenem, and heparin; acidic drugs such as vancomycin and parenteral nutrition (PN) solutions; ceftriaxone and calcium gluconate; and mineral precipitate in PN solutions with increased levels of calcium and phosphate.[1-5] (IV)
      c. Perform a gentle, pulsatile flush between infusions with 10 mL of preservative-free 0.9% sodium chloride (less in pediatric/neonatal, fluid restricted patients) or use separate catheter lumens, if available (refer to Standard 38, *Flushing and Locking*).
   4. Identify risk of lipid residue occlusion when administering lipid-containing infusions. Employ preventative strategies (eg, increased flushing) if lipid residue buildup is suspected.[1-5] (IV)

B. Assess for signs and symptoms of possible VAD occlusion:
   1. Inability to withdraw blood or sluggish blood return.[1,2,5] (IV)
   2. Sluggish flow; resistance or inability to flush lumen; inability to infuse fluid.[1,2,5] (IV)
   3. Frequent occlusion alarms on electronic infusion pump.[1,2] (V)
   4. Swelling/leaking at infusion site.[1,2,4] (V)
   5. No reflow or insufficient blood flow in hemodialysis central vascular access devices (CVADs).[3] (V)

48. Singh K, Bohl DD, Junyoung A, et al. Multimodal analgesia versus intravenous patient-controlled analgesia for minimally invasive transforaminal lumbar interbody fusion procedures. *Spine (Phila Pa 1976)*. 2017;42(15):1145-1150. doi:10.1097/BRS.0000000000001992
49. Firouzian A, Gholipour Baradari A, Alipour A, et al. Ultra-low-dose naloxone as an adjuvant to patient controlled analgesia (PCA) with morphine for postoperative pain relief following lumber discectomy: a double-blind, randomized, placebo-controlled trial. *J Neurosurg Anesthesiol*. 2018;30(1):26-31. doi:10.1097/ANA.0000000000000374
50. The Joint Commission. Pain assessment and management standards for nursing care centers. December 21, 2018. https://www.jointcommission.org/-/media/tjc/documents/standards/r3-reports/r3_21_pain_standards_ncc_12_21_18_final.pdf
51. The Joint Commission. Pain assessment and management standards for hospitals. August 29, 2017. https://www.jointcommission.org/standards/r3-report/r3-report-issue-11-pain-assessment-and-management-standards-for-hospitals/
52. The Joint Commission. Pain assessment and management standards for home health services. December 21, 2018. https://www.jointcommission.org/-/media/tjc/documents/standards/r3-reports/r3_22_pain_standards_hc_12_21_18_final.pdf
53. [No authors listed]. Fatal patient-controlled analgesia (PCA) opioid-induced respiratory depression. *AORN J*. 2021;114(1):108-110. doi:10.1002/aorn.13422
54. Lee Y, Kim K, Kim M. CE: Original research: errors in postoperative administration of intravenous patient-controlled analgesia: a retrospective study. *Am J Nurs*. 2019;119(4):22-27. doi:10.1097/01.NAJ.0000554523.94502.4c
55. Essex MN, Camu F, Borgeat A, Salomon PA, Pan S, Cheung R. The relationship between postoperative opioid consumption and the incidence of hypoxemic events following total hip arthroplasty: a post hoc analysis. *Can J Surg*. 2020;63(3):e250-e253. doi:10.1503/cjs.010519
56. Khanna AK, Bergese SD, Jungquist CR, et al. Prediction of opioid-induced respiratory depression on inpatient wards using continuous capnography and oximetry: an international prospective, observational trial. *Anesth Analg*. 2020;131(4):1012-1024. doi:10.1213/ANE.0000000000004788
57. Stites M, Surprise J, McNiel J, Northrop D, De Ruyter M. Continuous capnography reduces the incidence of opioid-induced respiratory rescue by hospital rapid resuscitation team. *J Patient Saf*. 2021;17(6):e557-e561. doi:10.1097/PTS.0000000000000408
58. Akcil EF, Korkmaz Dilmen O, Ertem Vehid H, Yentur E, Tunali Y. The role of "integrated pulmonary index" monitoring during morphine-based intravenous patient-controlled analgesia administration following supratentorial craniotomies: a prospective, randomized, double-blind controlled study. *Curr Med Res Opin*. 2018;34(11):2009-2014. doi:10.1080/03007995.2018.1501352
59. Messmer A, Ishak D. Nasal capnography during remifentanil patient-controlled analgesia in labour. *Int J Obstet Anesth*. 2017;32:91-92. doi:10.1016/j.ijoa.2017.03.006
60. Campoe KR, Giuliano KK. Impact of frequent interruption on nurses' patient-controlled analgesia programming performance. *Hum Factors*. 2017;59(8):1204-1213. doi:10.1177/0018720817732605

61. PARENTERAL NUTRITION

Standard

61.1 The decision to implement parenteral nutrition (PN) occurs in collaboration with the patient/caregiver and the health care team based on the projected treatment plan.

61.2 PN is administered using filtration and an electronic infusion pump with anti–free-flow control and appropriate alarms.

61.3 Medications are not added or co-infused with the PN solution before or during infusion without consultation with a pharmacist regarding compatibility and stability.

Practice Recommendations

A. Plan for safe and appropriate PN.
   1. Use the enteral route in preference to the parenteral route for nutrition support whenever feasible.[1-3] (IV)
   2. Recognize that PN is a complex and high-alert medication; reported incidents and errors that may lead to patient harm include microbial contamination, inappropriate prescriptions, and compounding and dispensing errors (see Standard 11, *Adverse and Serious Adverse Events*).[4-9] (IV)
   3. Ensure an interdisciplinary approach to promote safe use and encourage error reporting and error analysis to improve safety; nutritional support teams are associated with a reduction in catheter-related infection, inappropriate PN use, and reduced mortality.[5,7,10-12] (I)
   4. Use standardized order forms or templates and computerized order entry (COE) throughout the continuum of care whenever feasible, as they have been found to prevent errors related to PN prescriptions.[1,7,11,12] (V)
   5. Develop written protocols for PN component substitution or conservation methods in the event of drug/component shortage.[1,11,12] (V)
   6. Coordinate care using a patient-centered, interprofessional team approach for patients who will transition between health care settings (eg, acute care, skilled nursing facility, home, long-term acute care hospital).
      a. Address the following factors in the transition process: PN orders/formula, clinical status, appropriateness for patient setting, patient/caregiver education, available patient support, insurance coverage, appropriate vascular access device (VAD), and monitoring plan (eg, laboratory studies) (see Standard 66, *Home Infusion Therapy*).[1,12-14] (IV)

B. Administer PN safely.
   1. Plan for an appropriate VAD based upon expected duration of therapy, nutritional requirements, and the patient's vascular condition and preferences (see Standard 25, *Vascular Access Device Planning and Site Selection*).
      a. Consider a VAD with a minimal number of lumens.[3,11,15,16] (V)
      b. Consider peripherally inserted central catheters (PICCs) and tunneled, cuffed central vascular access devices (CVADs) for infants and

children who require prolonged PN during hospitalization.[15,17] (IV)

c. Consider tunneled, cuffed CVADs or PICCs for home parenteral nutrition (HPN) in both adults and children; implanted vascular access ports with the noncoring needle changed at least every 7 days may also be an option.[14-16,18-22] (V)

2. Administer peripheral PN (PPN) solutions/emulsions with a final concentration of 10% dextrose or lower through a PIVC as a bridge to central PN, when oral intake or enteral nutrition is suboptimal, or when the patient's clinical condition does not justify CVAD placement. Consider dextrose and other additives that affect osmolarity. The American Society for Enteral and Parenteral Nutrition (ASPEN) recommends not exceeding an osmolarity of 900 mOsm/L; studies show endothelial damage begins to occur at 600 mOsm/L. The osmolarity limit for PPN is an area of needed research.[1,3,11,23] (IV)
   a. Recognize the increased risk for phlebitis with PPN; weigh the risks vs benefits for PPN administration and limit duration of therapy to no more than 14 days. ASPEN recommendations do not address PPN administration via midline catheters.[1,3] (IV)
   b. Do not use midline catheters for continuous vesicant therapy, PN, or solutions with extremes of pH or osmolarity; the use of midline catheters for PPN is not established; the location of midline catheters in a deeper vein may mask early signs of phlebitis, extravasation, and thrombosis (refer to Standard 25, *Vascular Access Device Planning and Site Selection*).
3. Filter PN solutions and place the filter on the administration set as close to the patient as possible. Prime the filter in accordance with manufacturer's directions.[24,25] (IV)
   a. Use a 1.2-micron filter for all PN solutions, including dextrose-amino acid admixtures, lipid injectable emulsions (ILE), and PN solutions containing ILEs (also known as total nutrient admixture [TNA]).
4. Replace solution containers and administration sets used for PN (TNA and amino acid/dextrose formulations) and lipids every 24 hours; replace administration sets used for ILE with each new infusion. Hang time for PN should not exceed 24 hours.[1,11,14] (IV)
   a. In a laboratory study, TNA and ILE support *Candida albicans* growth after minimal initial contamination with microorganisms migrating from the fluid bag to the CVAD. Attention to Aseptic Non Touch Technique (ANTT®) during management of the administration set is imperative, and administration sets should be replaced daily (see Standard 40, *Administration Set Management*).[26] (IV)
   b. Limit separate ILE infusion to a 12-hour maximum time; if volume limitations require separate ILE administration for a period longer than 12 hours, ASPEN recommends strong consideration for a new ILE container and administration set for the second 12-hour portion. The hang time of a TNA can be extended to 24 hours because bacterial growth in these solutions is inhibited due to reduced pH and to increased total osmolarity compared to infusing ILE separately.[1,9] (V)
   c. Change the filter to coincide with initiation of a new PN mixture and administration set; change filters used for separately infused ILEs every 12 hours. Prime filters immediately before use.[24,25] (IV)
5. Use PN containers and administration sets free of Di[2-ethylhexyl]phthalate (DEHP) to administer lipid-based solutions, such as ILE or TNA. DEHP is a lipophilic toxin that can leach from commonly used polyvinyl chloride administration sets and containers into lipid-based solutions (see Standard 40, *Administration Set Management*).[1,8] (IV)
6. Protect PN admixtures from light for premature infants; degradation of PN components occurs with light exposure, resulting in oxidation; preterm infants are more susceptible than children and adults and face potential complications as a result of oxidative stress (eg, bronchopulmonary dysplasia, retinopathy, necrotizing enterocolitis).[1,27-30] (IV)
   a. ASPEN recommends complete PN light protection for preterm infants beginning during compounding and continuing until the entire PN/ILE infusion is complete (eg, during transport/delivery and administration). ASPEN acknowledges that full implementation may not be currently feasible, given product availability, but organizations should define what steps can be achieved and implement attainable strategies.
   b. While partial light protection does not offer clinical benefits, recommendations from ASPEN for non-preterm infants state to refrigerate and protect the PN solution from light exposure until just before infusion. There is a need for further studies about light protection for children and adults receiving long-term PN.
7. Use electronic infusion pumps with anti–free-flow protection and alarms for occlusion; consider the use of electronic infusion pumps with dose error reduction software (DERS) (ie, smart pumps), as they are associated with reduced risk for infusion-related medication errors, including error interceptions (eg, wrong rate), and reduced adverse drug events (refer to Standard 23, *Flow-Control Devices*).
8. Reduce the risk of catheter-associated bloodstream infection (CABSI) when administering PN.

a. Consider peripheral venipuncture for blood sampling instead of via the CVAD used for PN (see Standard 41, *Blood Sampling*).[1] (V)
   i. Adhere to ANTT if blood sampling via the CVAD is necessary; blood sampling via the CVAD is a quality-of-life issue for patients receiving long-term PN.[15] (IV)
b. Consider dedicating a single lumen to PN administration when a multilumen CVAD is in place.[3,14,15] (IV)
   i. Based upon a systematic review, data are insufficient to ascertain whether dedicating a lumen to PN results in a lower risk of infection; this remains an area of needed research.[31] (I)
c. Avoid attaching administration sets before the time of infusion; the risks of spiking containers and priming administration sets in advance has not been studied.[1,11] (V)
d. Consider antimicrobial lock therapy for patients receiving cyclic HPN as an infection-prevention strategy (see Standard 38, *Flushing and Locking*).
   i. Taurolidine was effective in prevention of catheter-related bloodstream infections (CR-BSIs) for patients on HPN and, while considered generally safe, rare allergic reactions and VAD-related problems, including pain, have been reported.[14,32-38] (I)
   ii. Other antimicrobials, including 4% tetrasodium, ethylenediaminetetraacetic acid (EDTA) and 70% ethanol (limited to patients with silicone CVADs) are also associated with reduced incidence of CR-BSI.[37-42] (I)
e. Consider CVAD repair for damaged subcutaneously tunneled, cuffed CVADs to extend CVAD survival and to reduce risk for future compromised vascular access. Retrospective studies have reported extension of CVAD survival without increased risk for central line-associated bloodstream infection (CLABSI) (see Standard 48, *Catheter Damage [Embolism, Repair, Exchange]*).[35,43-45] (IV)

C. Monitor the patient and provide patient education.
1. Monitor patient receiving PN for the following: body weight; fluid and electrolyte balance; metabolic tolerance, especially glucose control; VAD-related complications, including CABSI; organ function; nutrition therapy-related complications; functional performance; and psychological responses.[11,14,16,46-48] (IV)
2. Monitor blood glucose; when changing to a cyclic infusion, monitor on and off PN during initial cycling in the acute care or home setting; once stable, less frequent monitoring may be acceptable. Insulin may be used to control blood glucose levels and administered via the subcutaneous or intravenous (IV) route (may be added to PN solution).[1,47] (V)
3. Teach patients or family members of patients who receive home PN about importance of ANTT during all PN procedures, access device care, weight and hydration monitoring, blood/urine glucose monitoring, electronic infusion pump use and troubleshooting, and signs and symptoms to report; and assist patients on how to fit PN into their lifestyles (see Standard 8, *Patient Education*; Standard 19, *Aseptic Non Touch Technique [ANTT®]*; Standard 66, *Home Infusion Therapy*).[1,14,16,49,50] (IV)
4. Assess and address patient and family management and coping with HPN (refer to Standard 66, *Home Infusion Management*).

REFERENCES

1. Ayers P, Bobo ES, Hurt RT, Mays AA, Worthington PH. *Parenteral Nutrition Handbook.* 3rd ed. American Society for Parenteral and Enteral Nutrition; 2020.
2. Singer P, Blaser AR, Berger MM, et al. ESPEN guideline on clinical nutrition in the intensive care unit. *Clin Nutr.* 2019;38(1):48-79. doi:10.1016/j.clnu.2018.08.037
3. Worthington P, Balint J, Bechtold M, et al. When is parenteral nutrition appropriate? *JPEN J Parenter Enteral Nutr.* 2017;41(3):324-377. doi:10.1177/0148607117695251
4. Akbar Z, Saeed H, Saleem Z, Andleeb S. Dosing errors in total parenteral nutrition prescriptions at a specialized cancer care hospital of Lahore: the role of clinical pharmacist. *J Oncol Pharm Pract*. 2021;27(3):531-540. doi:10.1177/1078155220923014
5. Guenter P, Ayers P, Boullata JI, Gura KM, Holcombe B, Sacks GS. Parenteral nutrition errors and potential errors reported over the past 10 years. *Nutr Clin Prac.* 2017;32(6):826-830. doi:10.1177/0884533617715868
6. Mistry P, Smith RH, Fox A. Patient safety incidents related to the use of parenteral nutrition in all patient groups: a systematic scoping review. *Drug Saf*. 2022;45(1):1-18. doi:10.1007/s40264-021-01134-3
7. Ayers P, Boullata J, Sacks G. Parenteral nutrition safety: the story continues. *Nutr Clin Prac*. 2018;33(1):46-52. doi:10.1002/ncp.10023
8. Boullata JI, Mirtallo JM, Sacks GS, et al. Parenteral nutrition compatibility and stability: a comprehensive review. *JPEN J Parenter Enteral Nutr*. 2022;46(2):273-299. doi:10.1002/jpen.2306
9. Boullata JI, Berlana D, Pietka M, Klek S, Martindale R. Use of intravenous lipid emulsions with parenteral nutrition: practical handling aspects. *JPEN J Parenter Enteral Nutr.* 2020;44(S1):S74-S81. doi:10.1002/jpen.1737
10. Eriksen MK, Crooks B, Baunwall SMD, Rud CL, Lal S, Hvas CL. Systematic review with meta-analysis: effects of implementing a nutrition support team for in-hospital parenteral nutrition. *Aliment Pharmacol Ther.* 2021;54(5):560-570. doi:10.1111/apt.16530
11. Ukleja A, Gilbert K, Mogensen KM, et al. Standards for nutrition support: adult hospitalized patients. *JPEN J Parenter Enteral Nutr*. 2018;33(6):906-920. doi:10.1002/ncp.10204
12. Kumpf VJ. Challenges and obstacles of long-term parenteral nutrition. *JPEN J Parenter Enteral Nutr*. 2019;34(2):196-203. doi:10.1002/ncp.10258
13. Adams SC, Gura KM, Seres DS, et al. Safe care transitions for patients receiving parenteral nutrition. *Nutr Clin Prac.* 2022;37(3):493-508. doi:10.1002/ncp.10861
14. Pironi L, Boeykens K, Bozzetti F, et al. ESPEN guideline on home parenteral nutrition. *Clin Nutr*. 2020;39(6):1645-1666. doi:10.1016/j.clnu.2020.03.005

