TEXAS CHILDREN'S HOSPITAL
EVIDENCE-BASED OUTCOMES CENTER
Central Line-Associated Bloodstream Infection (CLABSI) Prevention Guideline
Evidence-Based Guideline

Definition: According to the Centers for Disease and Control, a central line-associated bloodstream infection (CLABSI) is a primary bloodstream infection in a person with a central venous catheter in the 48 hours preceding the infection that cannot be attributed to another cause. [(1)] In order to appropriately guide clinical care, this definition was modified. At TCH, a CLABSI is defined when a patient has a central line and has **one of the following criteria:**

- presence of a recognized pathogen cultured from one or more blood cultures; or
- signs/symptoms of an infection (i.e., fever, chills, or hypotension, especially when an infusion is running through the catheter) AND common skin commensal¥ is cultured from two or more blood cultures drawn on separate occasions; or
- if the ***child is ≤1 year*** and has signs/symptoms of an infection (i.e., fever, hypothermia, apnea, or bradycardia) AND common skin commensal^ is cultured from two or more blood cultures drawn on separate occasions.

Pathophysiology: The central line can become a pathogens portal of entry in order to cause a blood stream infection. The most common route of entrance is via the insertion site migrating through the catheter tract to cause colonization of the catheter tip. CLABSIs can also result from catheter colonization resulting from an infection in another location of the body. Other methods of catheter contamination include improper maintenance techniques such as contact with nonsterile surfaces, unclean hands or tainted infusate. [(1)]

Strict adherence to aseptic technique and CLABSI Prevention Bundle components can reduce the risk of infectious complications. [(2)] This guideline will provide recommendations for the prevention of central-line associated bloodstream infections (CLABSIs).

Epidemiology: According to data from all pediatric hospitals reporting healthcare-associated infections (HAIs) to the National Healthcare Safety Network (NHSN) from 2011 to 2014, the following pathogens accounted for more than 60% of HAIs: *Staphylococcus aureus* (17%), coagulase-negative staphylococci (17%), *Escherichia coli* (11%), *Klebsiella pneumoniae* and/or *oxytoca* (9%), and *Enterococcus faecalis* (8%). [(3)] Staphylococcal species were the most frequent for CLABSI. *Staphylococcus aureus* and coagulase-negative staphylococci were the most frequently reported CLABSI pathogens in critical care locations, viridans group streptococci and *K. pneumoniae/oxytoca* the most common in oncology wards, and *K. pneumoniae/oxytoca* the most common in pediatric wards.

Etiology: Patient characteristics, catheter type and location, maintenance of the catheter (including dressing selection and port/hub care), as well as institutional decisions related to staffing and patient cohorting can influence the rate of CLABSI. [(1)] The risk factors for CLABSI are below.

- Prematurity
- Age ≤1 year
- Emergency insertion or use
- Inadequate barriers for insertion
- Poor skin antisepsis
- Prolonged duration of use
- Catheter site
- Multiple lumens
- Excessive manipulation
- Neutropenia
- Receipt of total parenteral nutrition

Inclusion Criteria

- Patients with central venous access

Exclusion Criteria

- Patients on ECMO
- Patients with a VAD
- Patients with infections that do not meet the NHSN or CDC definitions for CLABSI
- Dialysis catheters
- Umbilical catheters (For direction on placement and management of umbilical catheters (UVC and UAC), refer to the Baylor Neonatology Service Guidelines for Acute Care of the Neonate.)

Assessment

A daily assessment of line necessity should be completed for all central venous catheters. Other aspects of assessment should include:

- Dressing integrity and skin around the dressing for redness, tenderness, swelling, and drainage.
- Reports of any discomfort including pain, abnormal sensations (such as tingling), numbness at or near the catheter insertion site.
- Skin underneath the dressing assessed with each dressing change.

Critical Points of Evidence*

Evidence Supports

Catheter Selection

- Selection of central line catheter type should be based upon the length of intended intravenous therapy, type of intravenous therapy needed, and the patient's/caregiver's ability to care for the catheter. [1,4-18] – Strong recommendation, low quality evidence
  Remarks: The guideline development team has developed an algorithm to guide clinicians in selection of the type of central line based upon recommended criteria. The team acknowledges that central lines placed in emergent situations may fall outside of the guidance for this topic.
- Consider antimicrobial-impregnated catheters on a case-by-case basis in patients with recurrent central line infections in the presence of good compliance with the central line maintenance bundle. [1,4-7,9,17,19-24] – Weak recommendation, moderate quality evidence
  Remarks: Evidence supports the use of minocycline-rifampin and chlorhexidine antimicrobial impregnated catheters for prevention of central line associated infections and other infectious outcomes over other types of impregnation. Catheter size and availability should be considered when deciding to use an impregnated catheter.

Maintenance

- Complete daily reassessments of the necessity of central lines and remove if no longer needed. [4,6,7,25-30] – Strong recommendation, low quality evidence
- Utilize a team of trained individuals for central line maintenance. [4,9,27,31-35] – Strong recommendation, very low quality evidence
- Use 3.15% chlorhexidine gluconate and 70% isopropyl alcohol solution (Prevantics) with a timed, 15-second dry time to cleanse hubs/ports. [1,4,6,7,9,36,37] – Strong recommendation, very low quality evidence
  Remarks: In 2015, the content expert team reviewed evidence comparing chlorhexidine to alcohol for cleansing hubs/ports. The team reviewed 6 studies and determined that chlorhexidine and alcohol were equally effective. [37-42] Practitioners were advised to consider the use of chlorhexidine in lieu of alcohol, as long as there were no contraindications to its use. In 2019, the question was modified to compare 3.15% chlorhexidine gluconate and 70% isopropyl alcohol solution (Prevantics) to alcohol.

Cap Disinfection and Change

- Change the cap on central venous access devices no more frequently than every 96 hours except in patients receiving blood products and/or lipids. For patients receiving blood products and lipids, change the cap on central venous access devices no more frequently than every 24 hours. [1,4,5,43] – Strong recommendation, low quality evidence

Ethanol Lock Therapy

- Ethanol therapy does not have a clinically significant effect on silicone catheters. [4,7,44-50] – Strong recommendation, low quality evidence
- The suggested minimum frequency to administer ethanol lock therapy in silicone catheters to prevent CLABSI is at least 3 times per week for a dwell time of 2-4 hours. [4,44,51-55] – Weak recommendation, low quality evidence
- See additional recommendations for ethanol lock therapy under the 'Evidence Against' section.

Rewire/Repair

- Consider rewiring the CVC only on a case-by-case basis due to a possible increased risk of complications. Contraindications to rewire include: history of CLABSI, current or recent thrombosis of the same site, immunocompromised patient, or evidence of infection (e.g., fever within previous 24-48 hours, positive culture). [1,4-7,9,56,57] – Weak recommendation, very low quality evidence

Dressings

- Use a chlorhexidine-impregnated dressing for patients >48 weeks corrected gestational age. [1,4-9,44,58-63] – Strong recommendation, moderate quality evidence

Evidence Against

Ethanol Lock Therapy

- Ethanol lock therapy should not be used in polyurethane catheters. Ethanol lock therapy has a negative effect on the integrity of polyurethane catheters. [4,7,44-50] – Strong recommendation, low quality evidence
- Ethanol lock therapy is contraindicated in the following patients/situations: receiving continuous infusions that cannot be interrupted, catheter size <2 French per lumen, polyurethane catheter, weight ≤5 kg, allergy to ethanol. [1,4,44,47,51,53,55] – Strong recommendation, very low quality evidence

Evidence Lacking/Inconclusive

Rewire/Repair

- Frequency and number of catheter repairs that increase the incidence for CLABSI. [64-67] – Unable to make a recommendation
  Remarks: Be cognizant of the number of times a central line has been repaired due to possible association with complications.

*NOTE: The references cited represent the entire body of evidence reviewed to make each recommendation.

Condition-Specific Elements of Clinical Management

General: Indications for central venous catheter placement include but are not limited to long-term parenteral nutrition, long-term antibiotic administration, chemotherapy administration, continuous vesicant or irritant administration, or hemodialysis. Central catheter selection should be made based upon the length of intended therapy, type of intravenous therapy needed, and the patient's/caregiver's ability to care for the catheter. [1,4-18] The four main categories of central lines are nontunneled, tunneled, peripherally inserted central catheters, and implanted ports. [9]

- **Nontunneled central catheters** are inserted via a peripherally into the subclavian, internal jugular or femoral vein and the catheter tip is advanced to the vena cava. Nontunneled central catheters are for short-term central venous access. [7,9]
- **Tunneled central catheters** are inserted into the subclavian, internal jugular, or femoral vein. The catheter end is tunneled under the skin and usually has an exit site in the chest. This type of catheter has a cuff which serves to stabilize the tubing and prevent migration of pathogens into the bloodstream. [1,7,9] Tunneled central catheters are surgically inserted or placed in Interventional Radiology and are for long-term central venous access.
- **Implantable ports** are surgically placed under the skin. Implantable ports connect to a catheter that enters one of the central veins and the catheter tip is advanced to the superior vena cava. Implantable ports are surgically inserted or placed in Interventional Radiology. This type of device is for long-term venous access. [7,9]
- **Peripheral inserted central catheters (PICCs)** are inserted into a peripheral vein and advanced to the vena cava. PICCs should be used for short-term venous access. [7,9]
- **Umbilical venous catheters (UVCs)** are inserted into the umbilical vein of newly born neonates within the first seven days of life. UVCs should be used for short-term venous access. [1]

Central Line Insertion Bundle [68]

- Verify the necessity of the central line daily.
- Adhere to aseptic technique.
- Perform proper hand hygiene.
- Utilize CHG skin antisepsis for all patients >28 weeks PMA, 1000 grams **and** age ≥7 days.
- Complete the insertion checklist.
- Ensure an observer is present to intervene if sterility is compromised.
- Utilize maximal sterile barriers including wearing hat, mask, gown, sterile gloves, and sterile full body drape covering the patient.
- Use appropriate dressing.

Central Line Maintenance Bundle [68]

- Discuss line necessity daily and document. Immediately remove any unnecessary central lines.
- Assess dressing hourly with infusion to assure it is clean, dry and intact.
- Assess the security of the luer-lock connections with every head-to-toe assessment.
- Bathe patient with chlorhexidine daily unless contraindicated, according to unit policy.
- Perform proper hand hygiene.
- Disinfect cap with 3.15% chlorhexidine gluconate and 70% isopropyl alcohol solution (Prevantics) before line entry utilizing a 15-second scrub and 15-second dry time.
- Use only sterile devices to access catheters.
- Utilize sterile gloves for dressing and cap change.
- Wear a mask during dressing, line and cap change.
- Limit line access as much as possible.
- Use nonsterile gloves for all line access (except cap change which requires sterile gloves).
- Cover all access ports (including tubing) with alcohol-impregnated caps.
- Tubing Change Frequency
  - Complete full tubing change every 96 hours.
  - Change lipid tubing every 24 hours.
  - Change intermittent medication tubing that is not disconnected from the line every 96 hours. If the tubing is disconnected from the line, it should be changed every 24 hours. Intermittent medication tubing in the Newborn Center should be changed every 24 hours.
  - Change tubing for blood product administration every 24 hours.
  - Change propofol tubing every 6-12 hours or when the bag/syringe is changed. [1]
- Sterile Cap Change Frequency
  - Active lumen (continuous and intermittent infusions) caps should be changed with tubing changes, prior to blood samples for cultures, and after blood product administration. For patients receiving blood products, change the cap on central venous access devices no more frequently than every 24 hours.
  - Lumens with lipid infusions should have a cap change every 24 hours based upon patient status, otherwise every 96 hours.
  - Lumens with propofol infusions should have the cap changed at the termination of therapy.
  - Dormant lumen (no medications except heparin per protocol) caps should be changed every 96 hours.
  - A cap should be replaced with a new sterile cap utilizing the sterile cap change kit.
- Dressing Changes
  - Change central line dressing every 7 days.

For additional information on the maintenance of central lines, please access the Care of the Patient with a Central Venous Catheter (CVC) Procedure.

Additional Measures for Prevention of CLABSI for Selected Populations

- Antimicrobial impregnated catheters can be considered on a case-by-case basis in patients with recurrent central line infections in the presence of good compliance with the central line maintenance bundle. [1,4-7,9,17,19-24]
- Ethanol lock therapy has been shown to decrease the risk of CLABSI in intestinal failure patients on long-term total parenteral nutrition.[52] If considering ethanol lock therapy, consult VAT. VAT should be consulted to determine and confirm intraluminal volume and catheter type prior to administering the first dose of the IV lock solution. Reported complications for ethanol lock therapy include, but are not limited to, increased catheter repair and replacement rate.[52] Call VAT team via page operator for any catheter complications. Below are guidelines for ethanol lock therapy at TCH.
  - Ethanol locks should only be utilized with silicone central venous devices. [4,7,44-50]
  - Ethanol lock therapy is contraindicated in the following patients/situations: receiving continuous infusions that cannot be interrupted, catheter size <2 French per lumen, polyurethane catheter, weight ≤5 kg, allergy to ethanol. [1,4,44,47,51,53,55]

- The use of ethanol lock therapy does not affect laboratory values as long as care is taken to follow proper protocol regarding serum waste and discard amount. [69-74]
- Ethanol lock therapy should be withdrawn from the catheter after the dwell period and discarded.
- There is no defined optimal frequency or dwell time for ethanol locks for the prevention of CLABSIs. The suggested minimum frequency is at least three times a week for a dwell time of 2-4 hours. [4,44,51-55]
- Care should be taken to ensure adequate flush amount when utilizing ethanol locks in patients that receive medications containing heparin and citrate due to precipitate formation and the risk of catheter occlusion.[75]

Consults/Referrals

If considering ethanol lock therapy, consult the Vascular Access Team (VAT).

Measures

Process

- Bundle compliance

Outcome

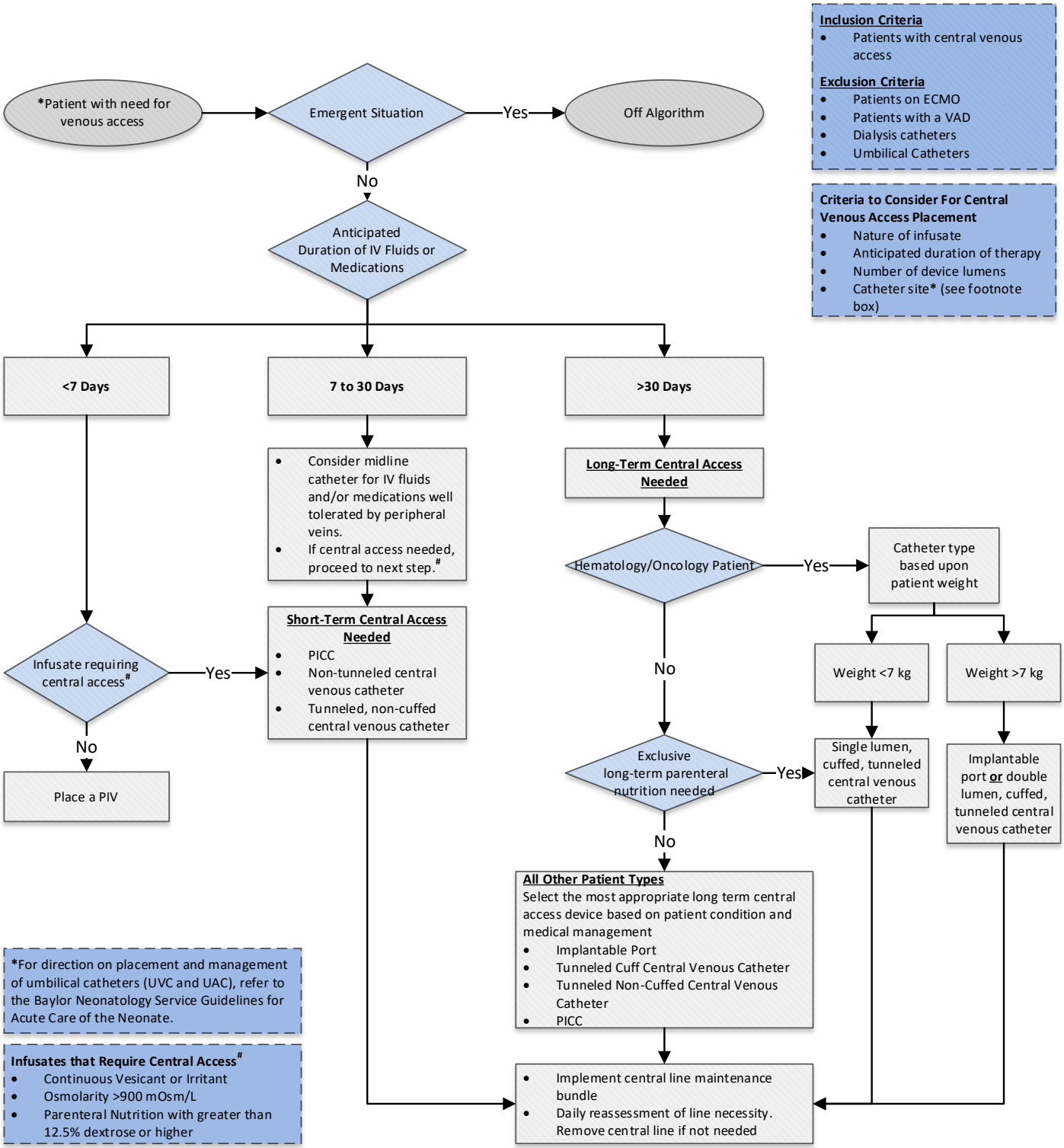
- CLABSI rate

Central Venous Catheters

Catheter Type	Entry Site	Duration of Use	Advantages	Disadvantages	Comments
Nontunneled CVCs	Percutaneously inserted into central veins	Short-term	Percutaneous insertion Relatively safe and inexpensive	Require local anesthesia May be inserted in the operating room Dressing required over site Risk of infection	CDC reports that this catheter type accounts for the majority of CLABSIs. This was not supported in a review of pediatric only studies. More commonly used than long-term CVCs
Tunneled CVCs	Implanted into internal jugular, subclavian, or femoral vein	Long-term	Dressing not needed after healed	Require surgical insertion Require local or general anesthesia Increased cost	Lower rate of infection than nontunneled CVCs Cuff inhibits migration of organisms into catheter tract
Implantable Ports	Inserted in the subclavian or internal jugular vein. Tunneled beneath the skin; subcutaneous port accessed with a non-coring needle	Long-term	Improved body image (low visibility of port) Patient comfort Local catheter site care and dressing not needed when not in use	Require surgical insertion and removal Require general anesthesia Increased cost	Lowest risk for CLABSI
Peripherally Inserted Central Catheter	Inserted percutaneously into basilic, brachial, or cephalic vein and enters the superior vena cava, or the saphenous, popliteal, or femoral vein and enters the inferior vena cava	Usually short-term to intermediate	Ease of insertion, usually at the bedside by a specially trained nurse Relatively inexpensive and safe	Can be difficult to position in central vein Potential for occlusion	CDC reports a lower rate of infection than nontunneled CVCs based upon adult studies. Our review of pediatric literature did NOT find PICCs to be superior to nontunneled CVCs.
Umbilical Venous Catheter	Inserted into the umbilical vein	Can be used up to 14 days with if managed aseptically	Large vessel in neonates that can be used for venous access	Serious complications can occur	Risk for CLABSI

Adapted from the CDC Guideline. [1]

TCH Evidence-Based Outcomes Center
Clinical Algorithm for Central Line-Associated Bloodstream Infection Prevention Guideline



Clinical standards are developed for 80% of the patient population with a particular disease. Each practitioner must use his/her clinical judgment in the management of any specific patient

References

1. Centers for Disease Control (CDC)/ Healthcare Infection Control Practices Advisory Committee (HICPAC). (2011 and 2017 Update). *Guidelines for the prevention of intravascular catheter-related infections*. https://www.cdc.gov/infectioncontrol/pdf/guidelines/bsi-guidelines-H.pdf
2. Jacob, J. T., & Gaynes, R. (2019, October 10). *Intravascular catheter-related infection: Prevention*. UpToDate. https://www.uptodate.com/contents/intravascular-catheter-related-infection-prevention?search=intravascular-catheter-relatedinfectionprevention&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1
3. Lake, J. G., Weiner, L. M., Milstone, A. M., Saiman, L., Magill, S. & See, I. (2018). Pathogen distribution and antimicrobial resistance among pediatric healthcare-associated infections reported to the National Healthcare Safety Network, 2011-2014. *Infection Control & Hospital Epidemiology, 39*(1), 1-11.
4. Infusion Nursing Society. (2016). *Infusion therapy standards of practice* (3rd ed.). Wolters Kluwer Health.
5. Schiffer, C., Mangu, P., Wade, J., Camp-Sorrell, D., Cope, D., El-Rayes, B., Gorman, M., Ligibel, J., Mansfield, P., & Levine, M. (2013). Central venous catheter care for the patient with cancer: American Society of Clinical Oncology Clinical Practice Guideline. *Journal of Clinical Oncology, 31*(10), 1357-1370.
6. American Society of Anesthesiologists Task Force on Central Venous Access; Rupp, S., Apfelbaum, J., Blitt, C., Caplan, R., Connis, R., Domino, K., Fleisher, L., Grant, S., Mark, J., Morray, J., Nickinovich, D., & Tung, A. (2012). Practice guidelines for central venous access: A report by the American Society of Anesthesiologists task force on central venous access. *Anesthesiology, 116*(3), 539-573.
7. Loveday, H., Wilson, J., Pratt, R., Golsorkhi, M., Tingle, A., Bak, A., Browne, J., Prieto, J., Wilcox, M., & UK Department of Health. (2014). Epic3: National evidence-based guidelines for preventing healthcare-associated infections in NHS hospitals in England. *Journal of Hospital Infection, 86* (Suppl 1), S1-S70.
8. Expert Panel on Interventional Radiology; Shaw, C., Shah, S., Kapoor, B., Cain, T., Caplin, D., Farsad, K., Knuttinen, M., Lee, M., McBride, J., Minocha, J., Robilotti, E., Rochon, P., Strax, R., Teo, E., & Lorenz, J. (2017). ACR appropriateness criteria® radiologic management of central venous access. *Journal of the American College of Radiology, 14* (11S), S506-S529.
9. The Joint Commission. (2012). *Preventing central line-associated bloodstream infections: A global challenge, a global perspective.* Joint Commission Resources. https://www.jointcommission.org/-/media/deprecated-unorganized/imported-assets/tjc/system-folders/topics-library/clabsi_monographpdf.pdf?db=web&hash=86103821F3C7FF8A7683C933EA0CB391
10. Hord, J., Lawlor, J., Werner, E., Billett, A., Bundy, D., Winkle, C., et al. (2016). Central line associated blood stream infections in pediatric hematology/oncology patients with different types of central lines. *Pediatric Blood and Cancer, 63*(9), 1603-1607.
11. Kelly, M., Conway, M., Wirth, K., Potter-Bynoe, G., Billett, A., & Sandora, T. (2013). Microbiology and risk factors for central line-associated bloodstream infections among pediatric oncology outpatients – A single institution experience of 41 cases. *Journal of Pediatric Hematology and Oncology, 35*(2), e71-e76.
12. Noonan, P., Hanson, S., Simpson, P., Dasgupta, M., & Peterson, T. (2018). Comparison of complication rates of central venous catheters versus peripherally inserted central venous catheters in pediatric patients. *Pediatric Critical Care Medicine, 19*(12), 1097-1105.
13. Orgel, E., Ji, L., Pastor, W., & Schore, R. (2014). Infectious morbidity by catheter type in neutropenic children with cancer. *Pediatric Infectious Disease Journal, 33*(3), 263-266.
14. Shah, S., West, A., Sepanski, R., Hannah, D., May, W., & Anand, K. (2015). Clinical risk factors for central line-associated venous thrombosis in children. *Frontiers in Pediatrics, 3*, 1-4.
15. Shenep, M., Tanner, M., Sun, Y., Culley, T., Hayden, R., Flynn, P., et al. (2017). Catheter-related complications in children with cancer receiving parenteral nutrition: Change in risk is moderated by catheter type. *Journal of Parenteral and Enteral Nutrition, 41*(6), 1063-1071.
16. Ullman, A., Marsh, N., Mihala, G., Cooke, M., & Rickard, C. (2015). Complications of central venous access devices: A systematic review. *Pediatrics, 136*(5), e1331-e1344.
17. Vidal, E., Sharathkumar, A., Glover, J., & Faustino, E. (2014). Central venous catheter-related thrombosis and thromboprophylaxis in children: A systematic review and meta-analysis. *Journal of Thrombosis and Haemostasis, 12*(7), 1096-1109.
18. Yamaguchi, R., Noritomi, D., Degaspare, N., Munoz, G., Porto, A., et al. (2017). Peripherally inserted central catheters are associated with lower risk of bloodstream infection compared with central venous catheters in paediatric intensive care patients: A propensity-adjusted analysis. *Intensive Care Medicine, 43*(8), 1097-1104.
19. Gilbert, R., Mok, Q., Dwan, K., Harron, K., Moitt, T., Millar, M., et al. (2016). Impregnated central venous catheters for prevention of bloodstream infection in children (the CATCH trial): A randomized controlled trial. *Lancet, 387*(10029), 1732-1742.
20. Gilbert, R., Brown, M., Rainford, N., Donohue, C., Fraser, C., Sinha, A., et al. (2019). Antimicrobial-impregnated central venous catheters for prevention of neonatal bloodstream infection (PREVAIL): An open-label, parallel-group, pragmatic, randomized controlled trial. *Lancet Child & Adolescent Health, 3*(6), 381-90.
21. Kramer, R. D., Rogers, M., Conte, M., Mann, J., Saint, S., & Chopra, V. (2017). Are antimicrobial peripherally inserted central catheters associated with reduction in central line-associated bloodstream infection? A systematic review and meta-analysis. *American Journal of Infection Control, 45*(2), 108-114.
22. Lai, N., Chaiyakunapruk, N., Lai, N., O'Riordan, E., Pau, W., & Saint, S. (2016). Catheter impregnation, coating or bonding for reducing central venous catheter-related infections in adults. *Cochrane Database of Systematic Reviews*, Issue 3. Art. No.: CD007878.
23. Shah, P., & Shah, N. (2014). Heparin-bonded catheters for prolonging the patency of central venous catheters in children. *Cochrane Database of Systematic Reviews*, Issue 2. Art. No.: CD005983.
24. Wu, G., Chen, Z., Sun, Y., Xiao, S., & Xia, Z. (2017). Impregnated central venous catheters in children: A systematic review of randomized controlled trials. *Intensive Care Medicine, 43*(8), 1159-1161.
25. Advani, S., Reich, N., Sengupta, A., Gosey, L., & Milstone, A. (2011). Central line-associated bloodstream infection in hospitalized children with peripherally inserted central venous catheters: Extending risk analyses outside the intensive care unit. *Clinical Infectious Diseases, 52*(9), 1108-1115.
26. Butler-O'Hara, M., D'Angio, C. T., Hoey, H., & Stevens, T. P. (2012). An evidence-based catheter bundle alters central venous catheter strategy in newborn infants. *Journal of Pediatrics, 160*(6), 972-977.
27. Greenberg, R., Cochran, K., Smith, P., Edson, B., Schulman, J., et al. (2015). Effect of catheter dwell time on risk of central line-associated bloodstream infection in infants. *Pediatrics, 136*(6), 1080-1086.
28. Milstone, A., Reich, N., Advani, S., Yuan, G., Bryant, K., et al. (2013). Catheter dwell time and CLABSIs in neonates with PICCs: A multicenter cohort study. *Pediatrics, 132*(6), e1609-e1615.
29. Niedner, M., Huskins, C., Colantuoni, E., Muschelli, J., Harris, M., et al. (2011). Epidemiology of central line-associated bloodstream infections in the pediatric intensive care unit. *Society for Healthcare Epidemiology of America, 32*(12), 1200-1208.
30. Sengupta, A., Lehmann, C., Diener-West, M., Perl, T., & Milstone, A. (2010). Catheter duration & risk of central line-associated bloodstream infection in neonates with PICCs. *Pediatrics, 125*(4), 648-653.
31. Holzmann-Pazgal, G., Kubanda, A., Davis, K., Khan, A. M., Brumley, K., & Denson, S. E. (2012). Utilizing a line maintenance team to reduce central-line-associated bloodstream infections in a neonatal intensive care unit. *Journal of Perinatology, 32*(4), 281-286.
32. Levit, O., Shabanova, V., & Bizzarro, M. (2019). Impact of a dedicated nursing team on central line-related complications in neonatal intensive care unit. *Journal of Maternal-Fetal & Neonatal Medicine, 7*, 1-5.

33. Secola, R., Azen, C., Lewis, M. A., Pike, N., Needleman, J., Sposto, R., et al. (2012). A crossover randomized prospective pilot study evaluating a central venous catheter team in reducing catheter-related bloodstream infections in pediatric oncology patients. *Journal of Pediatric Oncology Nursing, 29*(6), 307-315.
34. Taylor, T., Massaro, A., Williams, L., Doering, J., McCarter, R., He, J., et al. (2011). Effect of a dedicated percutaneously inserted central catheter team on neonatal catheter-related bloodstream infection. *Advances in Neonatal Care, 11*(2), 122-128.
35. Wilder, K. A., Wall, B., Haggard, D., & Epperson, T. (2016). CLABSI reduction strategy: A systematic central line quality improvement initiative integrating line-rounding principles and a team approach. *Advances in Neonatal Care, 16*(3), 170-177.
36. Sannoh, S., Clones, B., Munoz, J., Montecalvo, M., & Parvez, B. (2010). A multimodal approach to central venous catheter hub care can decrease catheter-related bloodstream infection. *American Journal of Infection Control, 38*(6), 424-429.
37. Soothill, J. S., Bravery, K., Ho, A., Macqueen, S., Collins, J., & Lock, P. (2009). A fall in bloodstream infections followed a change to 2% chlorhexidine in 70% isopropanol for catheter connection antisepsis: A pediatric single center before/after study on a hematopoietic stem cell transplant ward. *American Journal of Infection Control, 37*(8), 626-630.
38. Bishay, M., Retrosi, G., Horn, V., Cloutman-Green, E., Harris, K., De Coppi, P., et al. (2011). Chlorhexidine antisepsis significantly reduces the incidence of sepsis and septicemia during parenteral nutrition in surgical infants. *Journal of Pediatric Surgery, 46*(6), 1064-1069.
39. Curry, S., Honeycutt, M., Goins, G. & Gilliam, C. (2009). Catheter-associated bloodstream infections in the NICU: Getting to zero. *Neonatal Network, 28*(3), 151-155.
40. Hong, H., Morrow, D. F., Sandora, T. J., & Priebe, G. P. (2013). Disinfection of needleless connectors with chlorhexidine-alcohol provides long-lasting residual disinfectant activity. *American Journal of Infection Control, 41*(8), e77-e79.
41. Miller, M. R., Niedner, M. F., Huskins, W. C., Colantuoni, E., Yenokyan, G., Moss, M., et al. (2011). Reducing PICU central line-associated bloodstream infections: 3-year results. *Pediatrics, 128*(5), 1077-1083.
42. Pichler, J., Soothill, J., & Hill, S. (2014). Reduction of blood stream infections in children following a change to chlorhexidine disinfection of parenteral nutrition catheter connectors. *Clinical Nutrition, 33*(1), 85-89.
43. Sandora, T., Graham, D., Conway, M., Dodson, B., Potter-Bynoe, G., & Margossian, S. (2014). Impact of needleless connector change frequency on central line-associated bloodstream infection rate. *American Journal of Infection Control, 42*(5), 485-489.
44. Yokoe, D., Anderson, D., Berenholtz, S., Calfee, D., Dubberke, E., Ellingson, K., Gerding, D., Haas, J., Kaye, K., Klompas, M., Lo, E., Marschall, J., Mermel, L., Nicolle, L., Salgado, C., Bryant, K., Classen, D., et al. (2014). A compendium of strategies to prevent healthcare-associated infections in acute care hospitals: 2014 updates. *Infection Control & Hospital Epidemiology, 35*(8), 967-977.
45. Aiyangar, A., Crone, W., Crnich, C., & Maki. (n.d.) Effect of ethanol on the mechanical properties of polyurethane catheters. (Study provided by manufacture; no citation information available)
46. Crnich, C., Halfmann, J., Crone, W., & Maki, D. (2005). The effects of prolonged ethanol exposure on the mechanical properties of polyurethane and silicone catheters used for intravascular access. Infection Control and Hospital Epidemiology, 26(8), 708-714.
47. Kayton, M., Garmey, E., Ishill, N., Cheung, N., Kushner, B., et al. (2010). Preliminary results of a phase I trial of prophylactic ethanol-lock administration to prevent mediport catheter-related bloodstream infections. *Journal of Pediatric Surgery, 45*(10), 1961-1966.
48. Landry, D., Jaber, R., Hanumanthappa, N., Lipkowitz, G., O'Shea, M., Bermudez, H., Hathorne, A., & Braden, G. (2015). Effects of prolonged ethanol lock exposure to carbothane- and silicone-based hemodialysis catheters: A 26-week study. *Journal of Vascular Access, 16*(5), 367-371.
49. McHugh, G., Wild, D., & Havill, J. (1997). Polyurethane central venous catheters, hydrochloric acid and 70% ethanol: A safety evaluation. *Anaesthesia and Intensive Care, 25*(4), 350-353.
50. Msakni, N., Galmier, M., Couret, M., Szczepaniak, C., Bouchon, B., Souweine, C., et al. (2013). Complementary mass spectrometric approaches and scanning electron microscopy to study the structural stability of polyurethane tunneled dialysis catheters after exposure to ethanol solutions. *Rapid Communications in Mass Spectrometry, 27*(21), 2343-2354.
51. Lopes, B., Borges, P. S. G. N., Gallindo, R. M., Tenorio, T. B. S., Machado, L. B., & de Orange, F. A. (2019). Ethanol lock therapy for the prevention of nontunneled catheter-related bloodstream infection in pediatric patients. *Journal of Parenteral and Enteral Nutrition, 43*(8), 1044-1052.
52. Oliveira, C., Nasr, A., Brindle, M., & Wales, P. (2012). Ethanol locks to prevent catheter-related bloodstream infections in parenteral nutrition: A meta-analysis. *Pediatrics, 129*(2), 318-329.
53. Rahhal, R., Abu-El-Haija, M., Fei, L., Ebach, D., Orkin, S., et al. (2018). Systematic review and meta-analysis of the utilization of ethanol locks in pediatric patients with intestinal failure. *Journal of Parenteral and Enteral Nutrition, 42*(4), 690-701.
54. Ralls, M., Blackwood, A., Arnold, M., Partipilo, M., Dimond, J., & Teitelbaum, D. (2012). Drug shortage-associated increase in catheter-related blood stream infection in children. *Pediatrics, 130*(5), e1369-e1373.
55. Schoot, R., van Ommen, H., Stijnen, T., Tissing, W., Michiels, E., et al. (2015). Prevention of central venous catheter-associated bloodstream infections in paediatric oncology patients using 70% ethanol locks: A randomized controlled multi-centre trial. *European Journal of Cancer, 51*(14), 2031-2038.
56. McCoy, M., Bedwell, S., & Noori, S. (2011). Exchange of peripherally inserted central catheters is associated with an increased risk for bloodstream infection. *American Journal of Perinatology, 28*(6), 419-424.
57. O'Mara, M. S., Reed, N. L., Palmieri, T. L., & Greenhalgh, D. G. (2007). Central venous catheter infections in burn patients with scheduled catheter exchange and replacement. *Journal of Surgical Research, 142*(2), 341-350.
58. Biehl, L. M., Huth, A., Panse, J., Kramer, C., Hentrich, M., Engelhardt, M., et al. (2016). A randomized trial on chlorhexidine dressings for the prevention of catheter-related bloodstream infections in neutropenic patients. *Annals of Oncology, 27*(10), 1916-1922.
59. Duzkaya, D. S., Sahiner, N. C., Uysal, G., Yakut, T., & Citak, A. (2016). Chlorhexidine-impregnated dressings and prevention of catheter-associated bloodstream infections in a pediatric intensive care unit. *Critical Care Nurse, 36*(6), e1-e7.
60. Gerceker, G. O., Yardimci, F., & Aydinok, Y. (2017). Randomized controlled trial of care bundles with chlorhexidine dressing and advanced dressings to prevent catheter-related bloodstream infections in pediatric hematology-oncology patients. *European Journal of Oncology Nursing, 28*, 14-20.
61. Lai, N. M., Taylor, J. E., Tan, K., Choo, Y. M., Ahmad Kamar, A., & Muhamad, N. A. (2016). Antimicrobial dressings for the prevention of catheter-related infections in newborn infants with central venous catheters. *Cochrane Database of Systematic Reviews,* Issue 3, Art. No.: CD011082.
62. Rivas-Ruiz, R., Villasis Keever, M. A., Miranda Novales, M. G., Castelan Martinez, D., Vivanco Munoz, N., Chico Barba, G., et al. (2011). Efficacy of chlorhexidine gluconate impregnated patch for prevention of catheter-related infections in pediatric patients: Systematic review and met-analysis. *Boletin Medico del Hospital Infantil de Mexico, 68*(5), 349-355.
63. Safdar, N., O'Horo, J. C., Ghufran, A., Bearden, A., Didier, M. E., Chateau, D., et al. (2014). Chlorhexidine-impregnated dressing for prevention of catheter-related bloodstream infection: A meta-analysis. *Critical Care Medicine, 42*(7), 1703-1713.
64. Gnannt, R., Patel, P., Temple, M., Al Brashdi, Y., Amaral, J., Parra, D., et al. (2017). Peripherally inserted central catheters in pediatric patients: To repair or not repair. *Cardiovascular and Interventional Radiology, 40*(6), 845-851.
65. Lundgren, I. S., Zhou, C., Malone, F. R., McAfee, N. G., Gantt, S., & Zerr, D. M. (2012). Central venous catheter repair is associated with an increased risk of bacteremia and central line-associated bloodstream infection in pediatric patients. *Pediatric Infectious Disease Journal, 31*(4), 337-340.

66. McNiven, C., Switzer, N., Wood, M., Persad, R., Hancock, M., Forgie, S., et al. (2016). Central venous catheter repair is not associated with an increased risk of central line infection or colonization in intestinal failure pediatric patients. *Journal of Pediatric Surgery, 51*(3), 395-397.
67. Zens, T., Nichol, P., Leys, C., Haines, K., & Brinkman, A. (2019). Fractured pediatric central venous catheters - Repair or replace? *Journal of Pediatric Surgery, 54*(1), 165-169.
68. Centers for Disease Control (CDC) Bundle Checklist. Retrieved from https://www.cdc.gov/hai/pdfs/bsi/checklist-for-clabsi.pdf.
69. Jaffer, Y., Selby, N., Taal, M., Fluck, R., & McIntyre, C. (2008). A meta-analysis of hemodialysis catheter locking solutions in the prevention of catheter-related infection. *American Journal of Kidney Diseases*, *51*(2), 233-241.
70. Safdar, N., & Maki, D. (2006). Use of vancomycin-containing lock or flush solutions for prevention of bloodstream infection associated with central venous access devices: A meta-analysis of prospective, randomized trials. *Clinical Infectious Diseases, 43*(4), 474-484.
71. Opilla, M., Kirby, D., & Edmond, M. (2007). Use of ethanol lock therapy to reduce the incidence of catheter-related bloodstream infections in home parenteral nutrition patients. *Journal of Parenteral and Enteral Nutrition, 31*(4), 302-305.
72. McIntyre, C., Hulme, L., Taal, M., & Fluck, R. (2004). Locking of tunneled hemodialysis catheters with gentamicin and heparin. *Kidney International, 66*(2), 801-805.
73. Garland, J., Alex, C., Henrickson, K., McAuliffe, T., & Maki, D. (2005). A vancomycin-heparin lock solution for prevention of nosocomial bloodstream infection in critically ill neonates with peripherally inserted central venous catheters: A prospective, randomized trial. *Pediatrics, 116*, e198-e204.
74. Mouw, E., Chessman, K., Lesher, A., & Tagge, E. (2008). Use of an ethanol lock to prevent catheter-related infections in children with short bowel syndrome. *Journal of Pediatric Surgery, 43*, 1025-1029.
75. Cober, M. & Johnson, C. (2007). Stability of 70% alcohol solutions in polypropylene syringes for use in ethanol-lock therapy. *American Journal of Health-System Pharmacy, 64*, 2480-2482.

Clinical Standards Preparation

This clinical standard was prepared by the Evidence-Based Outcomes Center (EBOC) team in collaboration with content experts at Texas Children's Hospital. Development of this clinical standard supports the TCH Quality and Patient Safety Program initiative to promote clinical standards and outcomes that build a culture of quality and safety within the organization.

CLABSI Prevention Content Expert Team
Karla Abela, RN, ICU
Darlene Acorda, RN, ICU
Summer Alexander, MSN, RN, Newborn Center
Michael Braun, MD, Renal
Judith Campbell, MD, Infectious Diseases, Physician Co-lead
Dana Cerminara, PharmD, Pharmacy
Andrea Davis, MPH, Inpatient
Sheranda Fesler, RN, Nursing
Catherine Foster, MD, Infection Control
Gregory Gardner, MD, Radiology
Jordana Goldman, MD, Critical Care
Megha Kanjia, MD, Anesthesiology
Anne Lam, RN, ICU
Lucy Marquez, MD, Infection Control
Amy Mitchell, RN, Vascular Access Team
Brent Mothner, MD, Pediatric Hospital Medicine
Amir Pezeshkmehr, MD, Interventional Radiology
Courtney Prewitt, RN, Nursing
Nicole Riccioni, APRN, CPNP-PC, Interventional Radiology
Miranda Rodrigues, RN, CVICU
Brittany Rodriguez, PharmD, Pharmacy
Lauren Salinas, RN, CVICU
Mona Shah, MD, Hematology
Julia Shelburne, MD, Pediatric Hospital Medicine
Gautham Suresh, MD, Neonatology
Kristin Van Buren, MD, Gastroenterology
Sanjeev Vasudevan, MD, Surgery
Elaine Whaley, RN, Quality & Safety
EBOC Team

No relevant financial or intellectual conflicts to report.

Development Process

This clinical standard was developed using the process outlined in the EBOC Manual. The literature appraisal documents the following steps:

1. Review Preparation
   - PICO questions established
   - Evidence search confirmed with content experts

2. Review of Existing External Guidelines
   - American College of Radiology: Radiologic Management of Central Venous Access (2017); American Society of Anesthesiologists Task Force on Central Venous Access Practice: Guidelines for Central Venous Access (2012); American Society of Clinical Oncology: Central Venous Catheter Care for the Patient with Cancer (2013); CDC/Healthcare Infection Control Practices Advisory Committee (HICPAC): Guidelines for the Prevention of Intravascular Catheter-Related Infections (2011, 2017 Update); Infusion Nursing Society: Infusion Therapy Standards of Practice (2016); The Joint Commission: Preventing Central-Line Associated Bloodstream Infections (2012); Society of Healthcare Epidemiology of America: Strategies to Prevent Central Line-Associated Bloodstream Infections in Acute Care Hospitals (2014 Update); Society of Healthcare Epidemiology of America, IDSA, AHA, APIC, JC: A Compendium of Strategies to Prevent Healthcare-Associated Infections in Acute Care Hospitals (2014 Update); UK Department of Health Epic3: National Evidence-Based Guidelines for Preventing Healthcare-Associated Infections in NHS Hospitals in England (2014)

3. Literature Review of Relevant Evidence
   - Searched: PubMed, CINAHL, Google

4. Critically Analyze the Evidence
   - 11 meta-analyses, 8 randomized controlled trials, and 34 nonrandomized studies

5. Summarize the Evidence
   - Materials used in the development of the clinical standard, literature appraisal, and any order sets are maintained in a CLABSI Prevention evidence-based review manual within EBOC.

Evaluating the Quality of the Evidence

Published clinical guidelines were evaluated for this review using the **AGREE II** criteria. The summary of these guidelines are included in the literature appraisal. AGREE II criteria evaluate Guideline Scope and Purpose, Stakeholder Involvement, Rigor of Development, Clarity and Presentation, Applicability, and Editorial Independence using a 4-point Likert scale. The higher the score, the more comprehensive the guideline.
This clinical standard specifically summarizes the evidence *in support of* or *against* specific interventions and identifies where evidence is *lacking/inconclusive*. The following categories describe how research findings provide support for treatment interventions.
"Evidence Supports" provides evidence to support an intervention
"Evidence Against" provides evidence against an intervention.
"Evidence Lacking/Inconclusive" indicates there is insufficient evidence to support or refute an intervention and no conclusion can be drawn *from the evidence.*
The **GRADE** criteria were utilized to evaluate the body of evidence used to make practice recommendations. The table below defines how the quality of the evidence is rated and how a strong versus weak recommendation is established. The literature appraisal reflects the critical points of evidence.

Recommendation	
STRONG	Desirable effects clearly outweigh undesirable effects or vice versa
WEAK	Desirable effects closely balanced with undesirable effects
Quality	**Type of Evidence**
High	Consistent evidence from well-performed RCTs or exceptionally strong evidence from unbiased observational studies
Moderate	Evidence from RCTs with important limitations (e.g., inconsistent results, methodological flaws, indirect evidence, or imprecise results) or unusually strong evidence from unbiased observational studies
Low	Evidence for at least 1 critical outcome from observational studies, RCTs with serious flaws or indirect evidence
Very Low	Evidence for at least 1 critical outcome from unsystematic clinical observations or very indirect evidence

Recommendations

Practice recommendations were directed by the existing evidence and consensus amongst the content experts. Patient and family preferences were included when possible. The Content Expert Team and EBOC team remain aware of the controversies in the prevention of CLABSI in infants and children. When evidence is lacking, options in care are provided in the clinical standard and the accompanying order sets (if applicable).

Approval Process

Clinical standards are reviewed and approved by hospital committees as deemed appropriate for its intended use. Clinical standards are reviewed as necessary within EBOC at Texas Children's Hospital. Content Expert Teams are involved with every review and update.

Disclaimer

Practice recommendations are based upon the evidence available at the time the clinical standard was developed. Clinical standards (guidelines, summaries, or pathways) do not set out the standard of care and are not intended to be used to dictate a course of care. Each physician/practitioner should use his or her independent judgment in the management of any specific patient and is responsible, in consultation with the patient and/or the patient's family, to make the ultimate judgment regarding care.

Permission of Use

Version History

Date	Comments
Feb 2014	Completed the IV Lock Therapy Evidence Summary.
Feb 2015	Completed the CLABSI Prevention Evidence Summary.
Apr 2015	Completed the Central Line Complications Evidence Summary.
Feb 2021	Merged the Central Line Complications Evidence Summary, the CLABSI Prevention Evidence Summary, and the IV Lock Therapy Evidence Summary, and added new PICO questions on the topic of CLABSI prevention.