TEXAS CHILDREN'S HOSPITAL
EVIDENCE-BASED OUTCOMES CENTER
Diagnosis and Initial Management of Suspected
Central Line-Associated Bloodstream Infections (CLABSI)
Evidence-Based Guideline

Definition: A child is considered to have a CLABSI when the child has a central line and meets **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.

Modified from the CDC's surveillance definition of a CLABSI event to appropriately guide clinical care. **(1)**

¥diptheroids [*Corynebacterium* spp. not C. diptheriae], Bacillus spp. [not *B. anthracis*], *Propionibacterium* spp., coagulase-negative staphylococci [including *S. epidermis*], viridians group streptococci, *Aerococcus* spp., *Micrococcus* spp.

Pathophysiology: In the first week following catheter insertion, pathogens may migrate along the external surface of the catheter tubing and colonize it. Contamination of the hub followed by migration of pathogens into the lumen of the catheter may occur, usually more than 10 days after catheter insertion. Hematogenous seeding of the catheter by pathogens from another source also can be seen. Contamination of catheters from a contaminated infusate is rare. Risk factors for CLABSI include: prematurity, young age, emergency insertion, inadequate barriers for insertion, poor skin antisepsis, prolonged duration of use, catheter site, multiple lumens, excessive manipulation, neutropenia, and receipt of total parenteral nutrition. **(2-6)**

Epidemiology: Coagulase-negative staphylococci are the most common cause of CLABSI but infection with other gram-positive organisms (methicillin-susceptible and methicillin-resistant *Staphylococcus aureus*, enterococci, etc.) also occurs. Gram-negative organisms (*Escherichia coli*, *Klebsiella*, *Pseudomonas*, etc.) should be considered in all patients but especially in those who are neutropenic, severely ill, or known to be colonized with these pathogens. *Candida* species cause CLABSI most often in patients who are critically ill, have been on broad-spectrum antibiotic therapy, are receiving total parenteral nutrition, have a hematologic malignancy, or have received a bone-marrow or solid-organ transplant. Less virulent organisms such as *Bacillus* species, *Corynebacterium*, *Micrococcus* and Prioprionibacteria may also cause CLABSI. Mycobacteria, fungi and molds are less common but important causes of CLABSI in immunocompromised hosts. **(2,3,7-9)**

Inclusion Criteria
- Children with a central line‡ and signs of infection

Exclusion Criteria
- Children without a central line†

Differential Diagnosis
Fever and neutropenia
Urinary tract infection
Localized infection other than the intravascular catheter (e.g., pneumonia, intra-abdominal)

Diagnostic Evaluation
History: Assess for
- Presence of central line†
- Fever (e.g., sudden onset, no other obvious source)
- Positive blood cultures
- Local infection
- High grade bacteremia/fungemia
- Cluster of unusual Gram-negative bacteremias
- Patient is a likely candidate for sepsis
- Endocarditis and other metastatic infections acquired in hospital
- Rigors, especially with infusion through the central line

In the neonate, hypothermia, apnea, and bradycardia should be assessed as well.

†Central lines are an intravascular catheter that terminates at or close to the heart or in one of the following vessels: aorta, pulmonary artery, superior vena cava, inferior vena cava, brachiocephalic veins, internal jugular veins, subclavian veins, common iliac veins, femoral veins, and in neonates, the umbilical artery/vein. Central lines are used for infusion, withdrawal of blood or hemodynamic monitoring.

Diagnosis of CLABSI: Prior to initiating antibiotics, a central and a peripheral blood culture should be obtained simultaneously, when feasible (to assess time to positivity). If an adequate blood volume from a peripheral venipuncture cannot be obtained, the recommended total blood volume should be obtained from the central line. In the cases where equal and optimal blood volume has been obtained, time to positivity may provide useful information in detecting whether or not the central line can be preserved. Growth of microbes from a blood sample drawn from a catheter at least 2 hours before microbial growth is detected in a blood sample obtained from a peripheral vein best defines CLABSI. For children who have multiple lumens, obtaining a sample from each lumen can be considered, providing that obtaining an adequate blood volume is not compromised.
It's imperative that an adequate sample is obtained to optimize detection of the microorganism(s). (See Table 1 below.)

Table 1. Blood Volume for Culture by Body Weight

Weight in kg	Optimal total blood volume (ml)‡*	Volume of blood per bottle (ml)	Number and type of bottles NOTE: Priority should be given to the aerobic blood culture.
≤3	2	1	1 pediatric aerobic blood culture order (central) 1 pediatric aerobic blood culture order (peripheral)
>3-5	3	1.5	1 pediatric aerobic blood culture order (central) 1 pediatric aerobic blood culture order (peripheral)
>5-7	5	2.5	1 pediatric aerobic blood culture order (central) 1 pediatric aerobic blood culture order (peripheral)
>7-12	10	5	1 pediatric aerobic blood culture order (central) 1 pediatric aerobic blood culture order (peripheral)
>12-20	15	5	1 adult blood culture order^ (central) 1 pediatric aerobic blood culture order (peripheral)
>20-30	30	10	1 adult blood culture order^ (central) 1 pediatric aerobic blood culture order (peripheral)
>30-45	40	10	1 adult blood culture order^ (central) 1 adult blood culture order^ (peripheral)
>45	60	10	2 adult blood culture orders^ (central) 1 adult blood culture order^ (peripheral)

‡ per a 24 h time period
*max blood volume/DAY is 3-4 ml/kg of body weight (or 3.8% of total blood volume) **(10)**
^1 adult blood culture order includes, one aerobic bottle and one anaerobic bottle.
NOTE: The volume of blood drawn for culture is the most important variable in detecting bacteremia or fungemia. This observation is based on data published from multiple studies of adults. The recommended volume for an adult blood culture is 20 ml (2 adult bottles - one set) per culture, with a collection of 3 sets per episode.

Critical Points of Evidence*

TCH Evidence-Based Recommendations

Evidence Supports

- Obtain optimal blood volume for blood culture. [11-19] - Strong recommendation, high quality evidence
- In the cases where equal and optimal blood volume has been obtained, time to positivity may provide useful information in detecting whether or not the central line can be preserved. Growth of microbes from a blood sample drawn from a catheter at least 2 h before microbial growth is detected in a blood sample obtained from a peripheral vein best defines CLABSI. [20-26] - Strong recommendation, moderate quality evidence
- An anaerobic bottle should be obtained in addition to the aerobic bottle when volume permits. [18, 27-28] – Strong recommendation, low quality evidence
- Empiric antibiotic therapy should be administered in children with suspected CLABSI. [3,29] - Strong recommendation, moderate quality evidence
- Prompt removal of the central line should be considered when any of the following conditions and/or organisms exist: severe sepsis, suppurative thrombophlebitis, endocarditis, bloodstream infection that continues despite > 72 h of antimicrobial therapy to which the infecting microbes are susceptible, and infections due to *S.aureus*, *P. aeruginosa*, fungi, or mycobacteria, gram-negative bacilli, and enterococci. [3,30-32] - Strong recommendation, moderate quality evidence
- Priority should be given to obtaining the optimal amount of blood. Blood cultures should not be routinely obtained from multiple lumens if blood volume will be significantly impacted. [20, 33-36] - Weak recommendation, low quality evidence.
- Time to positivity or quantitative cultures should be utilized for detecting central line associated blood stream infections (CLABSI). [20-26] – Weak recommendation, low quality evidence
- One peripheral blood culture and one central blood culture should be obtained for work-up of suspected late-onset sepsis in infants with an indwelling central venous catheter. [20,33,37-41] – Strong recommendation, low quality evidence

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

Condition-Specific Elements of Clinical Management

General: Antibiotic therapy for suspected CLABSI should be initiated promptly after appropriate blood cultures are obtained. Blood cultures of optimal volume allow for better detection of pathogens causing CLABSI and, therefore, ensure optimal treatment of infection. The initial choice of antimicrobial therapy depends on the severity of the patient's illness, risk factors for infection including degree of immunosuppression and likely pathogens causing infection.

Treatment Recommendations:
Empiric Therapy [3,29]

- Vancomycin is recommended for empiric therapy due to the increased prevalence of methicillin-resistant staphylococci in our community.
- Empirical coverage for gram-negative bacilli should be based on the drug susceptibility history of child, local antimicrobial susceptibility data and the severity of disease
  - In chronically hospitalized patients who are not severely ill, and in whom repeated exposure to third-generation cephalosporins or broad-spectrum antibiotic therapy is not desirable, initial treatment with an aminoglycoside, such as gentamicin, is reasonable.
  - Patients who are severely ill or immune compromised cared for outside of the Newborn Center should receive empirical therapy with a third- (e.g., cefotaxime or ceftazidime) or fourth-generation (e.g., cefepime§) cephalosporin or a beta-lactam/beta-lactamase combination (e.g., piperacillin-tazobactam). Once culture and susceptibility data are available, de-escalation of antibiotic therapy can be performed, if feasible.
    §Cefepime is only available for non-neonatal patients treated at the Pavilion for Women.

- Empirical therapy for suspected catheter-related candidemia should be used for patients with neutropenia and fever lasting > 5 days. ([Fever and Neutropenia Guideline](#))
  - Risk factors for candidemia include:
    - total parental nutrition
    - prolonged use of broad-spectrum antibiotics
    - hematologic malignancy
    - receipt of bone marrow or solid organ transplant
    - femoral catheterization
    - colonization due to *Candida* species at multiple sites

Preserving/Removing the Central Line [3,30-32]
The benefits of catheter removal must be weighed against the difficulty of obtaining alternate venous access for each individual patient.

Prompt removal of the central line should be considered when any of the following conditions and/or organisms exists:
- Severe sepsis
- Endocarditis
- Bloodstream infection that continues despite > 72 h of antimicrobial therapy to which the infecting microbes are susceptible
- Infections due to *S. aureus*, gram-negative bacilli including *P. aeruginosa, Bacillus* species, and/or enterococci

Prompt removal of the catheter is necessary in cases of:
- Infections due to mycobacteria and/or fungi
- Tunnel site infection (e.g., redness, inflammation along catheter line, purulent drainage)
- Suppurative thrombophlebitis

Admission Criteria
- Children who are otherwise healthy with a central line and fever.
- Ill-appearing children with short gut who have a central line and fever should be admitted on antibiotics.

For ill-appearing children with hematology/oncology conditions, refer to Fever and Neutropenia Guideline.

Children with septic shock should be admitted to an intensive care unit. Children with suspected central line-associated bacteremia should be admitted to the area that can best address their medical needs given their physiologic status at the time of admission.

Measures
Process
- Utilization of the order set(s)
- Rate of contamination
- Rate of optimal blood volume obtained
- Rate of optimal blood volume obtained prior to initiation of antibiotics
- Rate of paired cultures (central and peripheral)

Outcome
- Length of stay
- Mortality rate
- Rate of admissions
- Time to positivity
- Rate of central line removals after CLABSI diagnosis

TCH Evidence-Based Outcomes Center
Clinical Algorithm for Diagnosis and Initial Management of Suspected Central Line Associated Bloodstream Infections (CLABSI)

Begin → Central line — No → **OFF algorithm** Manage as appropriate to clinical findings

Yes ↓
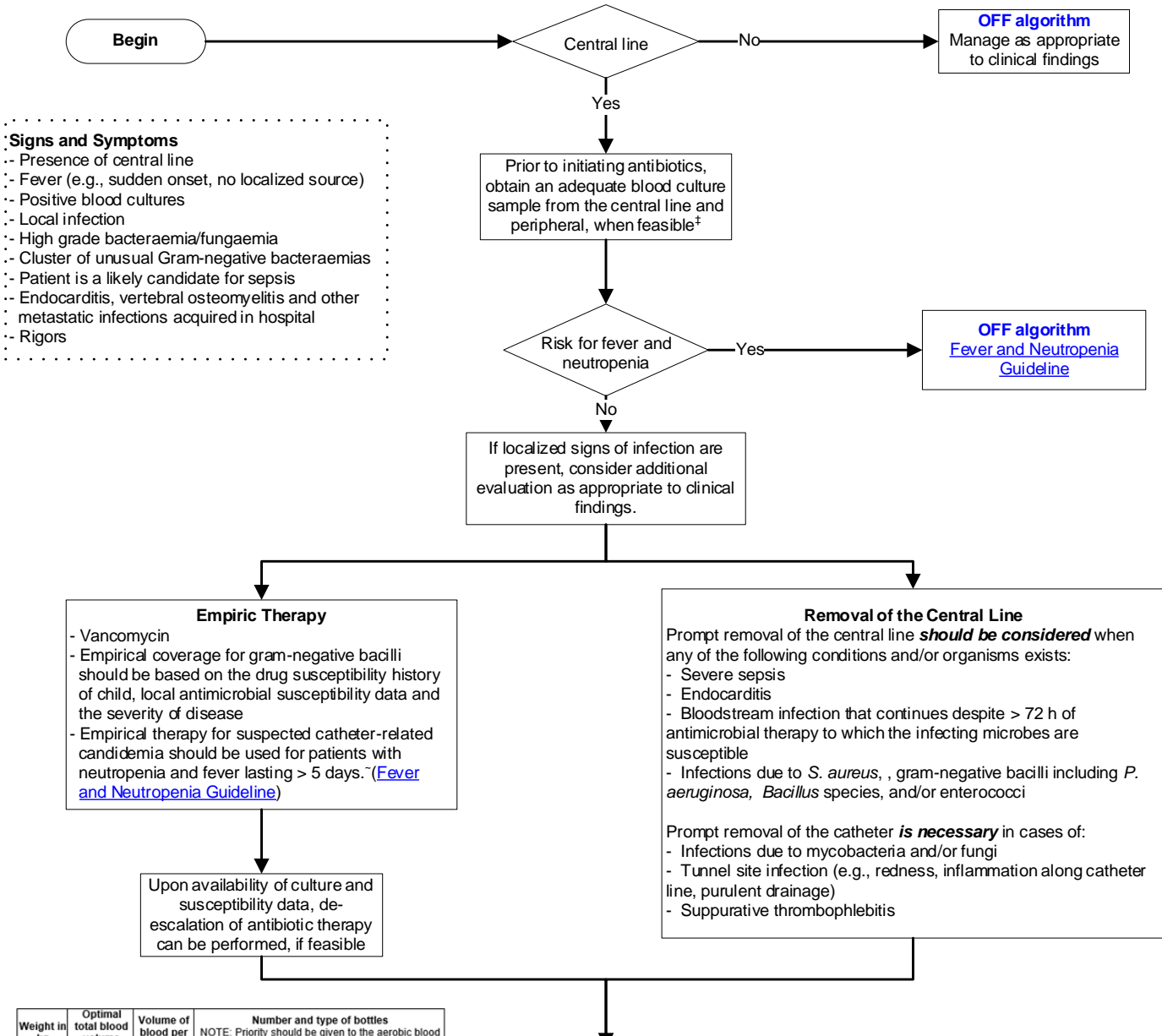
Signs and Symptoms
- Presence of central line
- Fever (e.g., sudden onset, no localized source)
- Positive blood cultures
- Local infection
- High grade bacteraemia/fungaemia
- Cluster of unusual Gram-negative bacteraemias
- Patient is a likely candidate for sepsis
- Endocarditis, vertebral osteomyelitis and other metastatic infections acquired in hospital
- Rigors

Prior to initiating antibiotics, obtain an adequate blood culture sample from the central line and peripheral, when feasible‡

↓

Risk for fever and neutropenia — Yes → **OFF algorithm** Fever and Neutropenia Guideline

No ↓

If localized signs of infection are present, consider additional evaluation as appropriate to clinical findings.

Empiric Therapy
- Vancomycin
- Empirical coverage for gram-negative bacilli should be based on the drug susceptibility history of child, local antimicrobial susceptibility data and the severity of disease
- Empirical therapy for suspected catheter-related candidemia should be used for patients with neutropenia and fever lasting > 5 days. (Fever and Neutropenia Guideline)

↓

Upon availability of culture and susceptibility data, de-escalation of antibiotic therapy can be performed, if feasible

Removal of the Central Line
Prompt removal of the central line **should be considered** when any of the following conditions and/or organisms exists:
- Severe sepsis
- Endocarditis
- Bloodstream infection that continues despite > 72 h of antimicrobial therapy to which the infecting microbes are susceptible
- Infections due to *S. aureus*, , gram-negative bacilli including *P. aeruginosa, Bacillus* species, and/or enterococci

Prompt removal of the catheter **is necessary** in cases of:
- Infections due to mycobacteria and/or fungi
- Tunnel site infection (e.g., redness, inflammation along catheter line, purulent drainage)
- Suppurative thrombophlebitis

Manage as appropriate to clinical findings

Risk factors for candidemia include:
- total parental nutrition
- prolonged use of broad-spectrum antibiotics
- hematologic malignancy
- receipt of bone marrow or solid organ transplant
- femoral cathertization
- colonization due to *Candida* species at multiple sites

Weight in kg	Optimal total blood volume (ml)‡*	Volume of blood per bottle (ml)	Number and type of bottles NOTE: Priority should be given to the aerobic blood culture.
≤ 3	2	1	1 pediatric aerobic blood culture order (central) 1 pediatric aerobic blood culture order (peripheral)
> 3-5	3	1.5	1 pediatric aerobic blood culture order (central) 1 pediatric aerobic blood culture order (peripheral)
> 5-7	5	2.5	1 pediatric aerobic blood culture order (central) 1 pediatric aerobic blood culture order (peripheral)
> 7-12	10	5	1 pediatric aerobic blood culture order (central) 1 pediatric aerobic blood culture order (peripheral)
> 12-20	15	5	1 adult blood culture order^ (central) 1 pediatric aerobic blood culture order (peripheral)
> 20-30	30	10	1 adult blood culture order^ (central) 1 pediatric aerobic blood culture order (peripheral)
> 30-45	40	10	1 adult blood culture order^ (central) 1 adult blood culture order^ (peripheral)
> 45	60	10	2 adult blood culture orders^ (central) 1 adult blood culture order^ (peripheral)

‡ per a 24 h time period
*max blood volume/DAY is 3-4 ml/kg of body weight (or 3.8% of total blood volume) [10]
^1 adult blood culture order includes, one aerobic bottle and one anaerobic bottle.
NOTE: The volume of blood drawn for culture is the most important variable in detecting bacteremia or fungemia. This observation is based on data published from multiple studies of adults. The recommended volume for an adult blood culture is 20 ml (2 adult bottles - one set) per culture, with a collection of 3 sets per episode.

References

1. CDC. (2012). Central Line-Associated Bloodstream Infection (CLABSI) Event. Accessed from http://www.cdc.gov/nhsn/pdfs/pscmanual/4psc_clabscurrent.pdf.
2. Centers for Disease Control and Prevention (CDC). (2011). Vital signs: Central line-associated blood stream infections--United States, 2001, 2008, and 2009. *MMWR Morbidity and Mortality Weekly Report, 60*(8), 243-8.
3. Mermel, L. A., Allon, M., Bouza, E., Craven, D. E., Flynn, P., O'Grady, N. P., et al. (2009). Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 update by the Infectious Diseases Society of America. *Clinical Infectious Diseases, 49*, 1-45.
4. Advani, S., Reich, N. G., Sengupta, A., Gosey, L., & Milstone, A. M. (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.
5. Tokars, J. I., Cookson, S. T., McArthur, M. A., Boyer, C. L., McGeer, A. J., & Jarvis, W. R. (1999). Prospective evaluation of risk factors for bloodstream infection in patients receiving home infusion therapy. *Annals of Internal Medicine, 131*(5), 340.
6. Wylie, M. C., Graham, D. A., Potter-Bynoe, G., Kleinman, M. E., Randolph, A. G., Costello, J. M., et al. (2010). Risk factors for central line-associated bloodstream infection in pediatric intensive care units. *Infection Control & Hospital Epidemiology. 31*(10), 1049-56.
7. Fontela, P. S., Platt, R. W., Rocher, I., Frenette, C., Moore, D., Fortin, E., et al. (2012). Epidemiology of central line-associated bloodstream infections in Quebec intensive care units: A 6-year review. *American Journal of Infection Control, 40*(3), 221-226.
8. Safdar, N., Mermel, L. A., & Maki, D. G. *The epidemiology of catheter-related infection in the critically ill.* In: O'Grady, N., & Pittet, D. (Eds.). Catheter-related infections in the critically ill. New York: Kluwer, 2004:1-23.
9. Wisplinghoff, H., Bischoff, T., Tallent, S. M., Seifert, H., Wenzel, R. P., & Edmond, M. B. (2004). Nosocomial bloodstream infections in US hospitals: Analysis of 24,179 cases from a prospective nationwide surveillance study. *Clinical Infectious Diseases, 39*(3), 309.
10. Howie, S. R. C. (2011). Blood sample volumes in child health research: Review of safe limits. *Bulletin of the World Health Organization, 89,* 46-53.
11. Connell, T. G., Rele, M., Cowley, D., Buttery, J. P., & Curtis, N. (2007). How reliable is a negative blood culture result? Volume of blood submitted for culture in routine practice in a children's hospital. *Pediatrics, 119*(5), 891-896.
12. Gonsalves, W. I., Cornish, N., Moore, M., Chen, A., & Varman, M. (2009). Effects of volume and site of blood draw on blood culture results. *Journal of Clinical Microbiology, 47*(11), 3482-3485.
13. Cockerill, F. R., Wilson, J. W., Vetter, E. A., Goodman, K. M., Torgerson, C. A., Harmsen, W. S., et al. (2004). Optimal testing parameters for blood cultures. *Clinical Infectious Diseases, 38*(12), 1724-1730.
14. Kellogg, J., Ferrentino, F., Goodstein, M., Liss, J., Shapiro, S., & Bankert, D. (1997). Frequency of low level bacteremia in infants from birth to two months of age. *The Pediatric Infectious Disease Journal, 16*(4), 381-385.
15. Kellogg, J. A., Manzella, J. P., & Bankert, D. A. (2000). Frequency of low-level bacteremia in children from birth to fifteen years of age. *Journal of Clinical Microbiology, 38*(6), 2181-2185.
16. Isaacman, D. J., Karasic, R. B., Reynolds, E. A., & Kost, S. I. (1996). Effect of number of blood cultures and volume of blood on detection of bacteremia in children. *The Journal of Pediatrics, 128*(2), 190-195.
17. Lee, A., Mirrett, S., Reller, L. B., & Weinstein, M. P. (2007). Detection of bloodstream infections in adults: How many blood cultures are needed? *Journal of Clinical Microbiology, 45*(11), 3546-3548.
18. Patel, R., Vetter, E. A., Harmsen, W. S., Schleck, C. D., Fadel, H. J., & Cockerill, F. R. (2011). Optimized pathogen detection with 30-compared to 20-milliliter blood culture draws. *Journal of Clinical Microbiology, 49*(12), 4047-4051.
19. Gaur, A., Giannini, M., Flynn, P., Boudreaux, J., Mestemacher, M., Shenep, J., et al. (2003). Optimizing blood culture practices in pediatric immunocompromised patients: Evaluation of media types and blood culture volume. *The Pediatric Infectious Disease Journal, 22*(6), 545-552.
20. Safdar, N., Fine, J. P., & Maki, D. G. (2005). Meta-analysis: Methods for diagnosing intravascular device-related bloodstream infection. *Annals of Internal Medicine, 142*(6), 451-466.
21. Abdelkefi, A., Achour, W., Ben Othman, T., Torjman, L., Ladeb, S., Lakhal, A., et al. (2005). Difference in time to positivity is useful for the diagnosis of catheter-related bloodstream infection in hematopoietic stem cell transplant recipients. *Bone Marrow Transplant, 35*(4), 397-401.
22. Guerti, K., Ieven, M., & Mahieu, L. (2007). Diagnosis of catheter-related bloodstream infection in neonates: A study on the value of differential time to positivity of paired blood cultures. *Pediatric Critical Care Medicine, 8*(5), 470-475.
23. Germanakis, I., Christidou, A., Galanakis, E., Kyriakakis, I., Tselentis, Y., & Kalmanti, M. (2005). Qualitative versus quantitative blood cultures in the diagnosis of catheter-related bloodstream infections in children with malignancy. *Pediatric Blood & Cancer, 45*(7), 939-944.
24. Gaur, A. H., Flynn, P. M., Giannini, M. A., Shenep, J. L., & Hayden, R. T. (2003). Difference in time to detection: A simple method to differentiate catheter-related from non-catheter-related bloodstream infection in immunocompromised pediatric patients. *Clinical Infectious Diseases, 37*(4), 469.
25. Gaur, A. H., Flynn, P. M., Heine, D. J., Giannini, M. A., Shenep, J. L., & Hayden, R. T. (2005). Diagnosis of catheter-related bloodstream infections among pediatric oncology patients lacking a peripheral culture, using differential time to detection. *Pediatric Infectious Disease Journal, 24*(5), 445-449.
26. Acuna, M., ORyan, M., Cofre, J., Alvarez, I., Benadof, D., Rodriquez, P., et al. (2008). Differential time to positivity and quantitative cultures for noninvasive diagnosis of catheter-related blood stream infection in children. *Pediatric Infectious Disease Journal, 27*(8), 681-685.
27. Cockerill, F. R., Hughes, J. G., Vetter, E. A., Mueller, R. A., Weaver, A. L., Ilstrup, D. M., et al. (1997). Analysis of 281,797 consecutive blood cultures performed over an eight-year period: Trends in microorganisms isolated and the value of anaerobic culture of blood. *Clinical Infectious Diseases, 24*(3), 403-418.28.
28. Creixems, M., Fron, C., Munoz, P., Sanchez, C., Pelaez, T., & Bouza, E. (2002). Use of anaerobically incubated media to increase yield of positive blood cultures in children. *The Pediatric Infectious Disease Journal, 21*(5), 443-446.
29. Texas Children's Hospital: Antibiotic Susceptibility Report. 2010.
30. Vasudevan C, McGuire W. Early removal versus expectant management of central venous catheters in neonates with bloodstream infection. *Cochrane Database of Systematic Reviews* 2011, Issue 8. Art. No.: CD008436. DOI: 10.1002/14651858.CD008436.pub2.
31. Adler, A., Yaniv, I., Solter, E., Freud, E., Samra, Z., Stein, J., et al. (2006). Catheter-associated bloodstream infections in pediatric hematology-oncology patients: Factors associated with catheter removal and recurrence. *Journal of Pediatric Hematology/Oncology, 28*(1), 23-28.
32. Nazemi, K. J., Buescher, E. S., Kelly, R. E., & Karlowicz, M. G. (2003). Central venous catheter removal versus in situ treatment in neonates with enterobacteriaceae bacteremia. *Pediatrics, 111*(3), e269-e274.
33. Falagas, M. E., Kazantzi, M. S., & Bliziotis, I. A. (2008). Comparison of utility of blood cultures from intravascular catheters and peripheral veins: A systematic review and decision analysis. *Journal of Medical Microbiology, 57*(1), 1-8.
34. Dobbins, B., Catton, J., Kite, P., McMahon, M., & Wilcox, M. (2003). Each lumen is a potential source of central venous catheter-related bloodstream infection. *Critical Care Medicine, 31*(6), 1688-1690.
35. Guembe, M., Rodriguez-Creixems, M., Carrillo, C. S., Parra, A. P., Martin-Rabadan, P., & Bouza, E. (2010). How many lumens should be cultured in the conservative diagnosis of catheter-related bloodstream infections? *Clinical Infectious Diseases, 50*(12), 1575-1579.

36. Robinson, J. (2002). Sensitivity of a blood culture drawn through a single lumen of a multilumen, long-term, indwelling, central venous catheter in pediatric oncology patients. *Journal of Pediatric Hematology/Oncology, 24*(1), 72-74.
37. Bizzarro, M., Shabanova, V., Baltimore, R., Dembry, L., Ekrenkranz, R., et al. Neonatal sepsis 2004-2013: The rise and fall of coagulase-negative staphylococci. *Journal of Pediatrics, 166*(5), 1193-1199.
38. Kumar, A., Sharma, R., Jaideep, C., & Hazra, N. (2014). Diagnosis of central venous catheter-related bloodstream infection without catheter removal: A prospective observational study. *Medical Journal Armed Forces India, 70*, 17-21.
39. Rodriquez, L., Ethier, M., Phillips, B., Lehrnbecher, T., Doyle, J., et al. (2012). Utility of peripheral blood cultures in patients with cancer and suspected blood stream infections: a systematic review. *Supportive Care in Cancer, 20*, 3261-3267.
40. Tarai, B., Das, P., Kumar, D., & Budhiraja, S. (2012). Comparative evaluation of paired blood culture (aerobic/aerobic) and single blood culture, along with clinical importance in catheter versus peripheral line at a tertiary care hospital. *Indian Journal of Medical Microbiology, 30*(2), 187-192.
41. Committee on Fetus and Newborn and the Committee on Infectious Diseases. (2012). American Academy of Pediatrics Technical Reports: Epidemiology and diagnosis of health care-associated infections in the NICU. *Pediatrics, 129*, e1104-e1109.

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.

Diagnosis and Management of Suspected Central Line-Associated Bloodstream Infections (CLABSI) Content Expert Team

Debra Palazzi, MD, Infectious Disease, Co-Chair
Paula Revell, MD, Pathology, Co-Chair
Donett Bell, CNS, RN, Acute Care
Debbie D'Ambrosio, RN, PICU
Paul Checchia, MD, Cardiology
Lakshmi Chandramohan, PhD, Pathology
Jonathan Crews, MD, Infectious Disease
Michael Distefano, MD, Emergency Medicine
Sara Fallon, MD, Surgery
Jeanine Graf, MD, Critical Care Medicine
Kathryne Hengstenberg, RN, Anesthesiology
Jose Hernandez, MD, Diagnostic Imaging
Joy Hesselgrave, CNS, RN, Cancer Center
Ryan Himes, MD, Hepatology, Gastroenterology and Nutrition
Yvette Johnson, MD, Neonatology
Alana Kennedy-Nasser, MD, BMT
Eugene Kim, MD, Surgery
Tjin Koy, Infection Control
Monica Lopez, MD, Surgery
Chrystal Louis, MD, Hematology/Oncology
Kathy McCarthy, RN, Cancer Center
Amy McCay, Neonatal Nurse Practitioner
Angela Morgan, RN, PICU
Barbara Montagnino, RN, PCU
Stacey Norris, RN, NICU
Robbie Norville, CNS, RN, Bone Marrow Transplant
Theresa Reed, RN, VAT Team
Amrita Singh, MD, Hospital Medicine
Kerry Sembera, RN, CVICU
Michael Speer, MD, Neonatology
Jeff Starke, MD, Infection Control
Liz Wuestner, RN, Emergency Center

EBOC Team

Andrea Jackson, MBA, RN, Evidence-Based Practice Specialist
Betsy Lewis, MSN, RN, CNL, Evidence-Based Practice Specialist
Sheesha Porter, MSN, RN, Evidence-Based Practice Specialist
Anne Dykes, MSN, RN, ACNS-BC, Manager
Warren Boudreau, MSN, RN, Director
Binita Patel, MD, Chief Medical Quality Officer

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
   - Infectious Disease Society of America (IDSA), Clinical Practice Guideline for the Diagnosis and Management of Intravascular Catheter-Related Infection: 2009 Update by the Infectious Disease Society of America, 2009; Seattle Children's Hospital, Diagnosis and Management of Central Line Associated Bloodstream Infections v.2.0, 2015; American Academy of Pediatrics, Report of the Committee of Infectious Diseases, 2015

3. Literature Review of Relevant Evidence
   - Searched: PubMed, Cochrane Database of Systematic Reviews, SumSearch, TripDatabase, Google Scholar, Infectious Disease Society of America (IDSA), AHRQ National Guideline Clearing House

4. Critically Analyze the Evidence
   - 5 meta-analyses and 26 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 Diagnosis and Management of Suspected Central Line-Associated Bloodstream Infections (CLABSI) 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 diagnosis and management of suspected central line-associated bloodstream infections in 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.

responsible, in consultation with the patient and/or the patient's family, to make the ultimate judgment regarding care.

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 must use his or her independent judgment in the management of any specific patient and is

Version History

Date	Comments
Jan 2013	Originally Completed
July 2021	Reaffirmed; PICO Question 1 and 4 archived