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Management of CRBSI: How to Extend the Lifeline for Home PN Patients

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Catheter-related bloodstream infections (CRBSI) are a dreaded complication for patients who require home parenteral nutrition (HPN) for survival. Patients with CRBSI usually present with fever, chills, and malaise. Clinicians should maintain a high level of suspicion for CRBSI to prevent severe illness and mortality. Healthcare providers should obtain blood cultures from both peripheral veins and the central venous access device (CVAD) at the first sign of infection. Antibiotic selection depends on the severity of the infection and antibiotic susceptibilities. Catheter salvage and preserving venous access have been proven successful in CRBSI. Establishing an institution-specific protocol for education, prevention, and treatment of CRBSI is essential for improving long-term outcomes of patients dependent on HPN.

INTRODUCTION

Home parenteral nutrition (HPN) is an alternative form of nutrition when enteral nutrition is infeasible or insufficient.[1,2] HPN improves quality of life and disease outcomes by optimizing patients' nutritional status.[1] In the United States, an estimated 20,883 adult patients received HPN in 2013 based on Medicare and Medicaid Services data.[3] Catheter-related bloodstream infection (CRBSI) is a significant cause of morbidity and mortality in patients receiving parenteral nutrition (PN).[4–9] The infections develop after microbial biofilms form on the surface of the central venous access devices (CVAD).[10] Studies have shown that patients receiving PN experience CRBSI at higher rates compared to other patients with chronic infusion needs.[3–5,11,12]

Many interventions reduce CRBSI and its mortality in the HPN population. Further, several societies have issued CRBSI guidelines, including the European Society for Clinical Nutrition and Metabolism (ESPEN), the American Society for Parenteral and Enteral Nutrition (ASPEN), and the Infectious Diseases Society of America (IDSA).[2,9,13] This review aims to provide an overview of the standard practices in diagnosing, treating, and preventing CRBSI.

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Epidemiology and Risk Factors

According to ASPEN's Sustain registry of both adult and pediatric HPN populations, black and male patients were more likely to have at least one episode of CRBSI.[14] Rates of CRBSI vary due to different diagnostic definitions, heterogeneity of study populations, and variability in institutional experience. In a meta-analysis, Reitzel et al. reported the incidence of CRBSI as 0.0-11.89 per 1000 CVAD days.[12] Known patient risk factors for CRBSI include having an ostomy or wound, underlying malignancy, and body mass index less than 18.5 kg/m.[2,15,16] Similarly, a retrospective study of 155 HPN patients established male sex and underlying malignancy as independent risk factors for CRBSI (HR 1.69 and 2.38 respectively, p= 0.009, <0.001).[17] In a Danish study of HPN patients, peripherally inserted central catheter (PICC) lines were associated with higher CRBSI rates (1.43 ± 0.20 vs. 0.95 ± 0.390, per 1000 CVAD days, $p < .001$) and shorter time intervals (83.91 ± 93.754 vs. 297.21 ± 386.910, $p < .001$) to a CRBSI episode compared to tunneled catheters.[18] Additionally, using intravenous lipid emulsion (ILE) more than twice weekly and catheters with multiple lumens may increase CRBSI.[16]

Making the Diagnosis

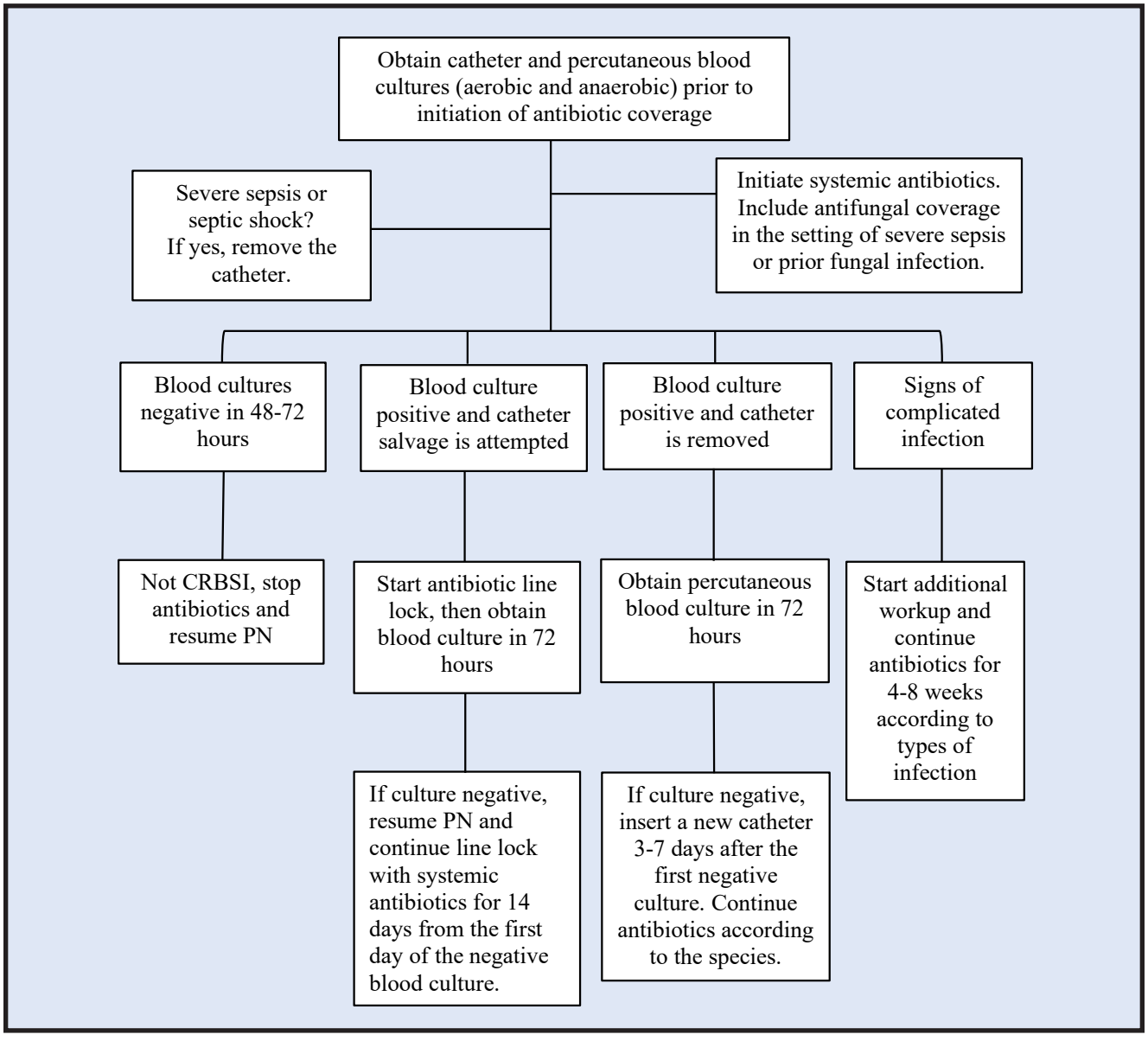
Promptly diagnosing CRBSI is crucial. However, diagnosing CRBSI is challenging due to multiple factors, including variable bacteria culture methods and lack of CVAD tip cultures when attempting to salvage the CVAD. Practitioners should maintain a high suspicion for CRBSI when patients report fever, rigor, and malaise, especially within 30 minutes of initiating an infusion.[4] However, clinical findings alone do not reliably establish a diagnosis. Fever and hypotension are sensitive but not specific. Purulent drainage at CVAD sites may solely indicate an exit-site infection without a concomitant bloodstream infection.[13] Further, an observational study of 548 adult patients on HPN at a Danish center employed six strict microbiological criteria based on different sources of blood culture methods. Out of 3,188 blood culture episodes obtained for clinical signs of infection, a mean blood culture positivity rate was only 40%, with 30% fulfilling a CRBSI diagnosis.[19]

When there is concern for CRBSI, it is imperative to obtain blood cultures before initiating antibiotics to diagnose CRBSI definitively (Figure 1). According to the IDSA, patients should have two sets of blood cultures drawn, with at least one set drawn percutaneously.[13] Notably, CVAD and percutaneous blood cultures have better negative predictive values than positive predictive values. Hence, a positive percutaneous culture must be interpreted within the clinical context, while a negative percutaneous culture is better at excluding a CRBSI (Table 1).[13,20]

Culturing the CVAD tip with quantitative or semi-quantitative methods is the most reliable approach to diagnosing CRBSI, but it is not readily available in many laboratories. Quantitative cultures utilize the highly accurate pour plate method.[4,13] According to the pour plate method, CRBSI occurs when CVAD and percutaneous cultures yield the same organisms, with CVAD colony counts at least 3-fold greater than percutaneous counts.[13] The differential time to positivity method is widely available among qualitative cultures. Microbial growth from the central CVAD blood sample occurring at least 2 hours earlier than the percutaneous blood sample provides a comparably accurate diagnosis to quantitative methods.[13,21,22] However, qualitative methods may falsely interpret contamination as an infection.[4] The IDSA guidelines recommend culturing the tip or a segment of the CVAD only when CRBSI is confirmed.[13] However, many patients require long-term access. A recent study showed that CVAD tip culture may not change antibiotic management when paired blood cultures confirm a CRBSI.[23] Therefore, septic shock or failed CVAD salvage should prompt performing CVAD tip cultures.

Finally, diagnosing certain pathogens requires specific blood culture protocols. A single blood culture growing coagulase-negative staphylococcus species necessitates additional blood samples from both the CVAD and a peripheral vein to rule out contamination. Patients with *Corynebacterium*, *Bacillus,* and *Micrococcus* species also require at least two positive blood cultures from different sites to secure a diagnosis.[13] *Malassezia furfur* is a lipophilic fungus within normal skin flora that is difficult to detect with routine blood culture methods. For patients with unexplained septic shock, it is important to perform a catheter tip

Figure 1. Protocol for Fever Workup and CRBSI Management in Patients Receiving PN



culture on Dixon agar to rule out *Malassezia furfur* fungemia.[24,25]

Management of CRBSI

Antibiotic Selection and Duration

After the appropriate blood cultures are obtained, intravenous antimicrobials should be started immediately in patients with signs of sepsis. The initial therapy should be tailored to the severity of the patient's clinical condition, the most likely pathogens, and the likelihood of resistant organisms based on the patient's history and the local antimicrobial resistance patterns. Coverage for gram-positive and gram-negative species with vancomycin and a fourth-generation cephalosporin is generally necessary.[13] Neutropenia, critical illness, or a history of multi-drug resistant pathogens warrant coverage for *Pseudomonas aeruginosa*. If the patient has a femoral CVAD and septic shock, empiric treatment should cover gram-negative bacilli and *Candida* species. Patients who develop severe sepsis should receive coverage for *Candida*.[13]

Following pathogen identification, the decision to remove or retain the CVAD should occur, as

well as distinguishing complicated CRBSI from uncomplicated CRBSI. Complicated infections include those with suppurative thrombophlebitis, endocarditis, and osteomyelitis.

The IDSA guideline in 2009 provides detailed approaches to specific pathogens. Notably, the most common causes of CRBSI are coagulase-negative staphylococci. Most staphylococci exhibit methicillin resistance. Regardless of resistance, staphylococci infections can be generally treated with 14 days of antibiotics if the CVAD is retained and 5-7 days if the CVAD is removed.[13] *Staphylococcus lugdunesis* and *Staphylococcus aureus* CRBSI require CVAD removal and generally 4-6 weeks of antibiotic treatment. Patients with *S. lugdunesis* and *S. aureus* are eligible for a shorter duration of antibiotics (2 weeks minimum) if they do not have diabetes, immunosuppression, prosthetic intravascular device, or complicated infections. These patients must resolve bacteremia within 72 hours of antibiotic initiation and a trans-esophageal echocardiogram (TEE) to ensure the absence of valvular vegetations. For CRBSI with *Enterococcus* species, ampicillin is the antibiotic of choice in non-resistant cases. In the presence of resistance, vancomycin is appropriate. The treatment is generally 7-14 days with CVAD retention. Signs or risks of endocarditis warrant evaluation with TEE. Critically ill patients with a history of gram-negative bacilli require two antibiotics of different classes with gram-negative activity to cover multidrug-resistant species. In addition, patients with a *Candida* CRBSI should have an ophthalmologic exam to assess for *Candida* endophthalmitis—patients on PN are at particular risk (odds ratio 6.02, interval 3.58-13.36).[26,27] Although societal guidelines recommended CVAD removal in *S. aureus*, *Pseudomonas*, and fungal species, many HPN patients struggle with limited vascular access sites. As such, there are cases of successful CVAD salvage in *Staphylococcus aureus*, *Pseudomonas,* and *Candida* species.[28,29]

When narrowing the antibiotic coverage, one should take special consideration in patients with short bowel syndrome because of decreased absorption of many oral antimicrobial therapies. Some patients, such as those having sufficient length of jejunum in continuity with more than half of the colon, may have adequate medication absorption.[30,31] In general, micro-emulsified and liquid formulations have better absorption, while lipid-soluble medications are often poorly absorbed.[31,32] Certain medications with high solubility and high permeability, such as levofloxacin and metronidazole, have better absorption in patients with short bowel.[31] Two systematic reviews similarly showed adequate absorption of metronidazole and fluconazole, whereas cephalexin, clindamycin, and trimethoprim-sulfamethoxazole had decreased absorption despite achieving therapeutic levels.[30,32,33] In contrast, ciprofloxacin and gentamicin had decreased bioavailability.[32,33] Comprehensive data in this area is limited as patients' anatomy varies. Individualized drug monitoring and subsequent dose titration are recommended. In addition, patients with severe dysmotility or bowel obstruction may also have difficulty tolerating oral antibiotics and require intravenous alternatives.

CRBSI Complications and Disseminated Diseases

Several severe complications of CRBSI require additional testing and management, including suppurative thrombophlebitis, endocarditis, and osteomyelitis. Suppurative thrombophlebitis entails a venous thrombus with persistent bacteremia despite at least three days of antimicrobial therapy. Radiographic evidence of the thrombus is necessary for the diagnosis. Patients should receive a minimum of 3-4 weeks of antibiotics. If the superficial vein is purulent or the infection extends beyond the vessel wall, the vessel should be surgically resected. The benefit of antithrombotic agents such as heparin is not clear.[13]

Patients with persistent bacteremia and prosthetic valves or implanted cardiac devices (pacemakers) should have endocarditis excluded with a TEE. TEE should happen at least one week from the initial positive blood culture to ensure the test's sensitivity. Notably, a negative transthoracic echocardiogram does not exclude endocarditis.[13]

Back pain, joint tenderness, or swelling raise the suspicion for osteomyelitis or septic arthritis in CRBSI. Serum biomarkers such as erythrocyte sediment rate and C-reactive protein are highly sensitive for osteomyelitis, but establishing the diagnosis requires radiographic studies such as

magnetic resonance imaging.[34] In septic arthritis, synovial fluid analysis and cultures are necessary.[35] Treatment of osteomyelitis typically involves 6-8 weeks of parenteral or highly bioavailable oral antibiotics. Likewise, both 2-4 weeks of antibiotics and surgical drainage are necessary for managing septic arthritis.[34,36,37]

Management of the CVADs

Septic shock, port abscesses, complicated CRBSI, or certain organisms, including *S. aureus*, *P. aeruginosa*, fungi, or mycobacteria, warrant removal of long-term CVAD.[2,13] Otherwise, IDSA and ESPEN guidelines support CVAD salvage since patients with HPN often require long-term venous access.[2,13] Of note, two studies did show comparable success rates of CVAD salvage in *S. aureus* infections.[28,29] Antibiotic lock therapy (ALT) may facilitate CVAD salvage. Ampicillin, cefazolin, and vancomycin locks are appropriate for gram-positive organisms. Cefazolin, ciprofloxacin, and gentamicin locks are usually suitable for gram-negative organisms. Tailoring line lock therapy to sensitivities from culture results is common.[38] In various institutional protocols, the duration of ALT ranged between 3 and 28 days.[29,38] The 2009 IDSA guidelines recommend ALT for 7-14 days in CVAD salvage with re-instillation every 24 hours, while the ESPEN guidelines in 2023 recommend 14 days of ALT with systemic antibiotics.[2,13] The success rates for salvage vary between 60% and 80%, with 53% of the patients CRBSI-free at one year.[38,39] Studies define successful salvage as clinical resolution of infection, negative blood cultures for 48 hours, and no evidence of CRBSI at 90 days after completing treatment.[4] While it is possible to salvage CVADs, CVAD salvage is associated with higher rates of new infections than CVAD removal.[39]

Salvage or wire exchange of a CVAD remains a viable option if patients have limited venous access sites or significant risks for procedural complications.[40] The overall success rate for CVAD salvage depends on the offending organisms: it ranges from 14.2% for *Candida* species, 26.7% in methicillin-resistant *S. aureus*, to 86.8% in methicillin-sensitive *S. aureus*.[28] The re-infection rate within 30 days was 4.4% in one study.[29] In the case of wire exchange, an antibiotic-impregnated CVAD is preferred.[13] Therefore, salvaging or exchanging a CVAD is often a multidisciplinary decision with interventional radiology and infectious disease providers. Finally, inserting a new CVAD should occur after blood cultures are negative for 2-3 days in patients who underwent CVAD removal, per IDSA guidelines.[13] Conversely, ESPEN recommends waiting 5-10 days after the first negative blood culture result or until the completion of the systemic antibiotic therapy before placing a new CVAD.[2]

Management of Parenteral Nutrition

During the initial evaluation for CRBSI, it is reasonable to hold PN and avoid accessing the retained CVAD. It is safe to resume PN after 72 hours of negative blood cultures following the initiation of appropriate antibiotic therapy.[29,38,39] Some institutions also withhold intravenous lipid emulsions (ILE) and continue a lipid-free PN solution when a patient has fever, leukocytosis, or sepsis but no evidence of bacteremia. The concern that ILE increases the risk of CRBSI or

Table 1. Criteria for CRBSI Diagnosis

Definition Met	Additional Criteria
Positive catheter tip culture	None required
Positive catheter blood culture and percutaneous culture with identical microorganisms	The colony count of the catheter specimen is at least 3-fold greater than the colony count from peripheral blood **OR** The catheter blood culture grows the organism at least two hours before the percutaneous culture
Percutaneous blood cultures and positive catheter tip with identical microorganisms	None required

worsens CRBSI outcomes underlies this practice. Historical studies suggest intravenous sunflower and safflower oil promote the growth of bacteria and *Candida*. Several early prospective studies showed a higher odds ratio of infection with ILE containing PN.[41,42] Mundi et al. summarized several potential mechanisms for the increased risk of infection associated with ILE.[3] Notably, ILE affects cell membrane fluidity and decreases the clearance capacity of the reticuloendothelial system, both of which can promote pro-inflammation.[43–45] However, in a prospective study with over 4000 patients, receiving ILE did not significantly contribute to bacteremia after adjusting for baseline characteristics.[46] Another retrospective study showed that ILE was not associated with higher rates of CRBSI, but patients with ILE had more frequent bloodstream infections from gastrointestinal translocation.[47] In addition, in a meta-analysis comparing the growth ratios of various species, only a portion of species survived exclusively in lipids. In contrast, some species rapidly grew in lipid-containing and lipid-free media.[48] Therefore, no substantial evidence supports withholding lipids in the case of suspected bacteremia or sepsis.

Table 2. Sample Patient Education Checklist[54,55]

Topic	Teaching Points
Catheter Care	• Hand hygiene • Aseptic technique – catheter flushing, preparation of the infusion bag, connection, and disconnection • Cleansing the catheter hub • Catheter cap placement and removal • Catheter insertion site care – dressing and line securement • Recognition of catheter complications
Home Environment	• Setting up a clean, hard (non-porous) area for aseptic infusion bag preparation • Restriction of animals from the area • Sanitary water supply • Safe refrigerated storage and inspection of infusion bags • Clean storage of infusion supplies
Patient-Purchased Supplies	• Liquid hand soap • Hand sanitizer • Paper towels • Antibacterial wipes

Prevention of CRBSI

Strategies for preventing HPN-associated CRBSI target known risk factors for CRBSI. For example, using a tunneled CVAD with the lowest number of lumens necessary may decrease CRBSI.[14,49] Another strategy for mitigating CRBSI is minimizing the frequency of accessing CVAD lumens by designating their use solely for PN or antibiotics.[16] ESPEN guidelines recommend taurolidine line locks for the primary prevention of CRBSI.[2] Several prospective studies demonstrate that taurolidine is superior to placebo and other line locks in preventing CRBSI and biofilm formation. Taurolidine is also cost-effective and has few adverse reactions.[50-52] Taurolidine line locks are currently unavailable in the United States. Conversely, the IDSA and ESPEN guidelines recommended against using ethanol locks to prevent CRBSI due to systemic toxicity and its potential to occlude or damage the CVAD.[2,13] Studies of line locks against *Candida* biofilms are mostly still in the pre-clinical stage.[53]

Clinician and patient education also play a crucial role in preventing CRBSI (Table 2).[50-52,54,55] Keohane et al. showed that teaching from a trained nurse decreased CRBSI rates from 11.5% in patients with tunneled CVADs to 4%.[49] In an Italian center, detailed training for HPN patients reduced CRBSI by 50% (6/1000 CVAD days to 3/1000 CVAD

days, p<0.005) compared with standard education. In a study by Reimund et al., CRBSI incidence decreased since the opening of a dedicated HPN center, and the rates were inversely related to the years of experience of the nutrition support team.[53]

CONCLUSION

Clinicians should employ accurate and prompt diagnostic and management tools to diagnose, treat, and prevent CRBSI and its complications in patients with PN. CVAD salvage is an evidenced-based strategy for preserving venous access. There are ongoing studies regarding effective CRBSI prevention strategies. A dedicated nutrition support team and institution-specific protocols can significantly reduce the risk of CRBSI in patients with PN. ■

References

1. Fojtová A, Norek B, Gazdíková K. The importance of home parenteral nutrition in clinical practice – own experience from our workplace. Gastroenterol Hepatol. 2022;76(1):60-66.
2. Pironi L, Cuerda C, Jeppesen PB, et al. ESPEN guideline on chronic intestinal failure in adults – Update 2023. Clin Nutr. 2023;42(10):1940-2021.
3. Mundi MS, Pattinson A, McMahon MT, Davidson J, Hurt RT. Prevalence of Home Parenteral and Enteral Nutrition in the United States. Nutr Clin Pract. 2017;32(6):799-805.
4. Bond A, Chadwick P, Smith TR, Nightingale JMD, Lal S. Diagnosis and management of catheter-related bloodstream infections in patients on home parenteral nutrition. Frontline Gastroenterol. 2020;11(1):48-54.
5. Dibb M, Lal S. Home Parenteral Nutrition: Vascular Access and Related Complications. Nutr Clin Pract. 2017;32(6):769-776.
6. Donaldson E, Taylor M, Abraham A, et al. Improving quality in a national intestinal failure unit: greater efficiency, improved access and reduced mortality. Frontline Gastroenterol. 2015;6(3):182-193.
7. Russell MK, Wischmeyer PE. Supplemental Parenteral Nutrition: Review of the Literature and Current Nutrition Guidelines: Nutrition in Clinical Practice. Nutr Clin Pract. 2018;33(3):359-369.
8. Bonnes SL, Salonen BR, Hurt RT, McMahon MT, Mundi MS. Parenteral and Enteral Nutrition—From Hospital to Home: Will It Be Covered? Nutr Clin Pract. 2017;32(6):730-738.
9. Kovacevich DS, Corrigan M, Ross VM, McKeever L, Hall AM, Braunschweig C. American Society for Parenteral and Enteral Nutrition Guidelines for the Selection and Care of Central Venous Access Devices for Adult Home Parenteral Nutrition Administration. J Parenter Enter Nutr. 2019;43(1):15-31.
10. Yousif A, Jamal MA, Raad I. Biofilm-Based Central Line-Associated Bloodstream Infections. In: Donelli G, ed. Biofilm-Based Healthcare-Associated Infections. Vol 830. Advances in Experimental Medicine and Biology. Springer International Publishing; 2015:157-179.
11. Ishizuka M, Nagata H, Takagi K, Kubota K. Total Parenteral Nutrition Is a Major Risk Factor for Central Venous Catheter-Related Bloodstream Infection in Colorectal Cancer Patients Receiving Postoperative Chemotherapy. Eur Surg Res. 2008;41(4):341-345.
12. Reitzel RA, Rosenblatt J, Chaftari A, Raad II. Epidemiology of Infectious and Noninfectious Catheter Complications in Patients Receiving Home Parenteral Nutrition: A Systematic Review and Meta-Analysis. J Parenter Enter Nutr. 2019;43(7):832-851.
13. Mermel LA, Allon M, Bouza E, et al. Clinical Practice Guidelines for the Diagnosis and Management of Intravascular Catheter-Related Infection: 2009 Update by the Infectious Diseases Society of America. Clin Infect Dis. 2009;49(1):1-45.
14. Ross VM, Guenter P, Corrigan ML, et al. Central venous catheter infections in home parenteral nutrition patients: Outcomes from Sustain: American Society for Parenteral and Enteral Nutrition's National Patient Registry for Nutrition Care. Am J Infect Control. 2016;44(12):1462-1468.
15. Xue Z, Coughlin R, Amorosa V, et al. Factors Associated With Central Line–Associated Bloodstream Infections in a Cohort of Adult Home Parenteral Nutrition Patients. J Parenter Enter Nutr. 2020;44(8):1388-1396.
16. Buchman AL, Opilla M, Kwasny M, Diamantidis TG, Okamoto R. Risk Factors for the Development of Catheter-Related Bloodstream Infections in Patients Receiving Home Parenteral Nutrition. J Parenter Enter Nutr. 2014;38(6):744-749.
17. Elfassy S, Kassam Z, Amin F, Khan KJ, Haider S, Armstrong D. Epidemiology and Risk Factors for Bloodstream Infections in a Home Parenteral Nutrition Program. J Parenter Enter Nutr. 2015;39(2):147-153.
18. Bech LF, Drustrup L, Nygaard L, et al. Environmental Risk Factors for Developing Catheter-Related Bloodstream Infection in Home Parenteral Nutrition Patients: A 6-Year Follow-up Study. J Parenter Enter Nutr. 2016;40(7):989-994.
19. Tribler S, Brandt CF, Hvistendahl M, et al. Catheter-Related Bloodstream Infections in Adults Receiving Home Parenteral Nutrition: Substantial Differences in Incidence Comparing a Strict Microbiological to a Clinically Based Diagnosis. J Parenter Enter Nutr. 2018;42(2):393-402.
20. DesJardin JA, Falagas ME, Ruthazer R, et al. Clinical Utility of Blood Cultures Drawn from Indwelling Central Venous Catheters in Hospitalized Patients with Cancer. Ann Intern Med. 1999;131(9):641.
21. Beekmann SE, Diekema DJ, Huskins WC, et al. Diagnosing and Reporting of Central Line–Associated Bloodstream Infections. Infect Control Hosp Epidemiol. 2012;33(9):875-882.
22. Raad I, Hanna HA, Alakech B, Chatzinikolaou I, Johnson MM, Tarrand J. Differential Time to Positivity: A Useful Method for Diagnosing Catheter-Related Bloodstream Infections. Ann Intern Med. 2004;140(1):18.
23. Ulrich P, Lepak AJ, Chen DJ. Diagnostic and Therapeutic Utility of Positive Intravascular Catheter Tip Cultures. Carroll KC, ed. Microbiol Spectr. 2022;10(6):e04022-22.
24. Rhimi W, Theelen B, Boekhout T, Otranto D, Cafarchia C. Malassezia spp. Yeasts of Emerging Concern in Fungemia. Front Cell Infect Microbiol. 2020;10:370.
25. Iatta R, Battista M, Miragliotta G, Boekhout T, Otranto D, Cafarchia C. Blood culture procedures and diagnosis of Malassezia furfur bloodstream infections: Strength and weakness. Med Mycol. 2018;56(7):828-833.
26. Pappas PG, Kauffman CA, Andes DR, et al. Clinical Practice Guideline for the Management of Candidiasis: 2016 Update by the Infectious Diseases Society of America. Clin Infect Dis. 2016;62(4):e1-e50.
27. Phongkhun K, Pothikamjorn T, Srisurapanont K, et al. Prevalence of Ocular Candidiasis and Candida Endophthalmitis in Patients With Candidemia: A Systematic Review and Meta-Analysis.

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Clin Infect Dis. 2023;76(10):1738-1749.
28. Edakkanambeth Varayil J, Whitaker JA, Okano A, et al. Catheter Salvage After Catheter-Related Bloodstream Infection During Home Parenteral Nutrition. J Parenter Enter Nutr. 2017;41(3):481-488.
29. Dibb MJ, Abraham A, Chadwick PR, et al. Central Venous Catheter Salvage in Home Parenteral Nutrition Catheter-Related Bloodstream Infections: Long-Term Safety and Efficacy Data. J Parenter Enter Nutr. 2016;40(5):699-704.
30. Severijnen R, Bayat N, Bakker H, Tolboom J, Bongaerts G. Enteral Drug Absorption in Patients with Short Small Bowel: A Review. Clin Pharmacokinet. 2004;43(14):951-962.
31. Meade U, Gabriel N, Patel R, et al. Drug Absorption in Patients with a Short Bowel. In: Nightingale JMD, ed. Intestinal Failure. Springer International Publishing; 2023:699-716.
32. Hong WBT, Tan WK, Law LSC, Ong DEH, Lo EAG. Changes of Drug Pharmacokinetics in Patients with Short Bowel Syndrome: A Systematic Review. Eur J Drug Metab Pharmacokinet. 2021;46(4):465-478.
33. Korzilius JW, Gompelman M, Wezendonk GTJ, et al. Oral antimicrobial agents in patients with short bowel syndrome: worth a try! J Antimicrob Chemother. 2023;78(8):2008-2014.
34. Berbari EF, Kanj SS, Kowalski TJ, et al. 2015 Infectious Diseases Society of America (IDSA) Clinical Practice Guidelines for the Diagnosis and Treatment of Native Vertebral Osteomyelitis in Adultsa. Clin Infect Dis. 2015;61(6):e26-e46.
35. Parvizi J, Tan TL, Goswami K, et al. The 2018 Definition of Periprosthetic Hip and Knee Infection: An Evidence-Based and Validated Criteria. J Arthroplasty. 2018;33(5):1309-1314.e2.
36. Gjika E, Beaulieu JY, Vakalopoulos K, et al. Two weeks versus four weeks of antibiotic therapy after surgical drainage for native joint bacterial arthritis: a prospective, randomised, non-inferiority trial. Ann Rheum Dis. 2019;78(8):1114-1121.
37. Mathews CJ, Coakley G. Septic arthritis: current diagnostic and therapeutic algorithm. Curr Opin Rheumatol. 2008;20(4):457-462.
38. Gompelman M, Paus C, Bond A, et al. Comparing success rates in central venous catheter salvage for catheter-related bloodstream infections in adult patients on home parenteral nutrition: a systematic review and meta-analysis. Am J Clin Nutr. 2021;114(3):1173-1188.
39. Ait Hammou Taleb MH, Mahmutovic M, Michot N, Malgras A, Nguyen-Thi PL, Quilliot D. Effectiveness of salvage catheters in home parenteral nutrition: A single-center study and systematic literature review. Clin Nutr ESPEN. 2023;56:111-119.
40. Martínez E, Mensa J, Rovira M, et al. Central venous catheter exchange by guidewire for treatment of catheter-related bacteraemia in patients undergoing BMT or intensive chemotherapy. Bone Marrow Transplant. 1999;23(1):41-44.
41. Battistella FD, Widergren JT, Anderson JT, Siepler JK, Weber JC, MacColl K. A Prospective, Randomized Trial of Intravenous Fat Emulsion Administration in Trauma Victims Requiring Total Parenteral Nutrition: J Trauma Inj Infect Crit Care. 1997;43(1):52-60.
42. McCowen KC, Friel C, Sternberg J, et al. Hypocaloric total parenteral nutrition: Effectiveness in prevention of hyperglycemia and infectious complications—A randomized clinical trial: Crit Care Med. 2000;28(11):3606-3611.
43. Calder PC, Yaqoob P, Harvey DJ, Watts A, Newsholme EA. Incorporation of fatty acids by concanavalin A-stimulated lymphocytes and the effect on fatty acid composition and membrane fluidity. Biochem J. 1994;300(2):509-518.
44. Wanten GJ, Naber AHJ. Human Neutrophil Membrane Fluidity After Exposure to Structurally Different Lipid Emulsions. J Parenter Enter Nutr. 2001;25(6):352-355.
45. Seidner DL, Mascioli EA, Istfan NW, et al. Effects of Long-Chain Triglyceride Emulsions on Reticuloendothelial System Function in Humans. J Parenter Enter Nutr. 1989;13(6):614-619.
46. Pontes-Arruda A, Dos Santos MCFC, Martins LF, et al. Influence of Parenteral Nutrition Delivery System on the Development of Bloodstream Infections in Critically Ill Patients: An International, Multicenter, Prospective, Open-Label, Controlled Study—EPICOS Study. J Parenter Enter Nutr. 2012;36(5):574-586.
47. Gavin NC, Larsen E, Runnegar N, et al. Association between parenteral nutrition–containing intravenous lipid emulsion and bloodstream infections in patients with single-lumen central venous access: A secondary analysis of a randomized trial. J Parenter Enter Nutr. 2023;47(6):783-795.
48. Austin PD, Hand KS, Elia M. Systematic review and meta-analyses of the effect of lipid emulsion on microbial growth in parenteral nutrition. J Hosp Infect. 2016;94(4):307-319.
49. Keohane PP, Attrill H, Northover J, et al. Effect of catheter tunneling and a nutrition nurse on catheter sepsis during parenteral nutrition. The Lancet. 1983;322(8364):1388-1390.
50. Daoud DC, Wanten G, Joly F. Antimicrobial Locks in Patients Receiving Home Parenteral Nutrition. Nutrients. 2020;12(2):439.
51. Bisseling TM, Willems MC, Versleijen MW, Hendriks JC, Vissers RK, Wanten GJ. Taurolidine lock is highly effective in preventing catheter-related bloodstream infections in patients on home parenteral nutrition: A heparin-controlled prospective trial. Clin Nutr. 2010;29(4):464-468.
52. Wouters Y, Theilla M, Singer P, et al. Randomised clinical trial: 2% taurolidine versus 0.9% saline locking in patients on home parenteral nutrition. Aliment Pharmacol Ther. 2018;48(4):410-422.
53. Rosenblatt J, Reitzel R, Vargas-Cruz N, Chaftari AM, Hachem R, Raad I. Comparative Efficacies of Antimicrobial Catheter Lock Solutions for Fungal Biofilm Eradication in an in Vitro Model of Catheter-Related Fungemia. J Fungi. 2017;3(1):7.
54. Nickel B, Gorski L, Kleidon T, et al. Infusion Therapy Standards of Practice, 9th Edition. J Infus Nurs. 2024;47(1S):S1-S285.
55. Gorski LA. A Look at 2021 Infusion Therapy Standards of Practice. Home Health Now. 2021;39(2):62-71.

Answers to this month's crossword puzzle:

1 Z	E	2 N	K	3 E	R	4 S	■	5 E	L	6 L	I	7 S	O	8 N
O	■	Y	■	R	■	9 T	L	C	■	I	■	E	■	E
10 L	A	C	11 T	A	S	E	■	12 H	E	P	A	T	I	C
L	■	■	R	■	■	A	■	I	■	■	■	O	■	K
13 I	L	14 E	U	15 S	■	16 T	E	N	E	S	M	U	17 S	■
N	■	18 N	E	T	■	O	■	O	■	■	■	19 T	E	N
20 G	E	T	■	R	■	21 R	E	C	T	22 A	L	■	N	■
E	■	E	■	23 E	A	R	■	O	■	C	■	■	24 S	25 P
R	■	26 R	O	T	■	27 H	O	C	■	28 C	O	29 V	E	R
■	■	O	■	30 T	I	E	■	C	■	R	■	E	■	O
31 X	Y	S	M	A	■	32 A	N	O	33 R	E	C	T	A	L
R	■	C	■	■	■	■	■	34 S	A	T	■	■	■	A
35 A	N	O	D	36 E	■	37 J	O	I	N	I	N	38 G	U	P
Y	■	P	■	T	■	E	■	S	■	O	■	U	■	S
39 S	C	Y	B	A	L	U	M	■	40 E	N	Z	Y	M	E