Clinical Guidelines

<AT>American Society for Parenteral and Enteral Nutrition Guidelines for the Selection and Care of Central Venous Access Devices for Adult Home Parenteral Nutrition Administration

<AU>Debra S. Kovacevich, MPH, RN[1]; Mandy Corrigan, MPH, RD, LD, CNSC, FAND[2]; Vicki M. Ross, PhD, RN[3]; Liam McKeever, MS, RDN[4]; Amber M. Hall, MS[5]; and Carol Braunschweig, PhD, RD[4]

<AF>From the [1]Home Care Services, Michigan Medicine, University of Michigan School of Nursing and College of Pharmacy, Ann Arbor, Michigan; [2]Center for Human Nutrition, Home Nutrition Support & Center for Gut Rehabilitation and Transplant, Cleveland, Ohio; [3]Nutrition Support Nurse Consultant, Shawnee Mission, Kansas; [4]Department of Kinesiology and Nutrition, University of Illinois at Chicago, Chicago Illinois; and the [5]University of North Carolina Chapel Hill, Raleigh Durham, North Carolina.

Financial disclosure: There was no funding or contribution from industry, nor were any industry representatives present at any of the committee meetings.

Conflicts of interest: All authors completed both the ASPEN conflict of interest form for copyright assignment and financial disclosure. The authors of these guidelines have reported all potential conflicts or financial disclosures.

<CA>Corresponding Author:

Carol Braunschweig, PhD, RD, Department of Kinesiology and Nutrition, University of Illinois at Chicago, 1919 Taylor Street (M\C 517), Chicago, IL 60048.

Email: braunsch@uic.edu

<AB>Abstract:

This document represents the American Society of Parenteral and Enteral Nutrition (ASPEN) clinical guidelines to describe best practices in the selection and care of central venous access devices (CVADs) for the infusion of home parenteral nutrition (HPN) admixtures in adult patients. The guidelines targeted adults >18 years of age in which the intervention or exposure had to include HPN that was administered via a CVAD. Case studies, non-English studies, or studies of CVAD no longer available in the United States were excluded. In total,

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1002/jpen.1455.

564 abstract citations, 350 from Medline and 214 from PubMed/non-MEDLINE databases, were scanned for relevance. Of the 564 citations, 13 studies addressed at least 1 of the 6 guideline-related questions, and none of the studies were prospective and randomized. The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) criteria were used to adjust the evidence grade based on assessment of the quality of study design and execution. Recommendations for the CVAD type, composition, or number of lumens to minimize infectious or mechanical complications are based on a limited number of studies and expert opinion of the authors, all very experienced in home infusion therapy. No studies were found that compared best solutions for routine flushing of lumens (eg, heparin versus saline) or for maintaining catheters in situ while treating CVAD mechanical or infectious complications. It is clear that studies to answer these questions are very limited, and further research is needed. These clinical guidelines were approved by the ASPEN Board of Directors. (*JPEN J Parenter Enteral Nutr.* 2018;XX:xxx-xxx)

<KW>Keywords

adults; antibiotic locks; catheter flushing; catheter related blood stream infection; catheter salvage; central line associated blood stream infection (CLABSI); central venous access device; central venous access device lumens; central venous access device types; central venous access material; ethanol locks; guidelines; home parenteral nutrition

<H1>PRELIMINARY REMARKS (INTENT OF GUIDELINES)

This document represents the American Society of Parenteral and Enteral Nutrition (ASPEN) Clinical Guidelines to describe best practices in the selection and care of central venous access devices (CVADs) for the infusion of home parenteral nutrition (HPN) solutions in the adult patient. The mission of ASPEN is to improve patient care by advancing the science and practice of clinical nutrition and metabolism.

<H2>Guideline Limitations: These ASPEN Clinical Guidelines are based on general consensus among a group of professionals who, in developing such guidelines, have examined the available literature on the subject and balanced potential benefits of nutrition practices against risks inherent with such therapy. These practice guidelines are not intended as absolute policy statements. Use of these practice guidelines does not in any way guarantee any specific benefit in outcome or survival. The professional judgment of the

attending health professional is the primary component of quality medical care delivery. Since guidelines cannot account for every variation in circumstances, practitioners must always exercise professional judgment when applying these recommendations for individual patients. These Clinical Guidelines are intended to supplement, but not replace, professional training and judgment.

The guidelines reflect an exhaustive search of the research literature for evidence about the best practices related to CVADs used in the care of adult HPN patients. Many of the reports excluded from analyses were anecdotal, describing diverse experiences of heterogeneous groups of HPN patients without data to address the guideline questions. Studies addressing the guideline questions were analyzed and used to develop recommendations. Recommendations reflect a review and analysis of the current literature and a blend of expert opinion and clinical practicality. The population of adult home patients receiving parenteral nutrition (PN) is not homogeneous. These guidelines represent a review of published research through September 9, 2017, about the selection and care of CVADs. All of the reviewed studies were observational; no prospective randomized clinical trials were found that addressed questions about CVADs used for HPN.

A comprehensive search of the medical literature yielded 13 prospective or retrospective cohort studies that provided data about CVADs used for HPN administration in adults. Study quality and data were critically reviewed by a group of multidisciplinary experts in clinical nutrition composed of nurses, dietitians, and a biostatistician. These individuals used the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) methodology to develop consensus-derived recommendations.[1]

<H1>Methods

The GRADE process was used to develop key questions and plan data acquisition and conflation for these guidelines.[1] The task force of experts began by defining language used for the routine care and complications associated with CVADs and keywords to be used for the literature search. This was followed by: 1) development of the key questions that were the focus of this clinical guideline; 2) establishing a time frame that would be used for the literature search; 3) determining the target population (inclusion and exclusion criteria); and 4) establishing the specific outcomes that would be addressed. Ultimately, 6 questions were developed by the guideline experts and approved by the ASPEN Board of Directors. These questions and their recommendations are summarized in Table 1.

All included studies were prospective or retrospective investigations of clinical outcomes tailored to address specific questions. The GRADE criteria were used to adjust the evidence based on assessment of the quality of study design and execution. The GRADE approach separates the evidence compiled from the recommendation statements, enabling independent assessment of the weight of the risks versus (vs) the benefits that occur from adopting the recommendation. All recommendations that were based solely on expert opinion were deemed as very low. Table 2 describes the standard language and rationale for the grade assigned to a recommendation.

The Centers for Disease Control (CDC) and the Infusion Nurses Society (INS) have guidelines and standards that include the insertion, maintenance, care, and surveillance monitoring for CVAD complications (https://www.cdc.gov/infectioncontrol/guidelines/bsi/updates.html). Their recommendations are based on the strength of the study design. They include information regarding some of the questions that were identified in these guidelines. However, the majority of their focus is based heavily on the acute care setting rather than care in the home. Establishing guidelines for use in the home creates unique challenges as care is provided by patients and caregivers with little or no medical background, and the environment, supplies, equipment, and reimbursement are different compared with hospital settings.

<H2>Definition

Home nutrition support therapy refers specifically to the provision of parenteral PN through a CVAD in a homecare setting.

<H2>Target Patient Population for Guidelines

The target of these guidelines is to determine the type of CVAD that is associated with the lowest occurrence of infectious and mechanical complications in adult (>18 years of age) patients receiving HPN. Studies that evaluated pediatric HPN and inpatient PN populations were excluded. These guidelines are directed toward generalized outpatient populations but, like any other management strategy, the infusion therapy selected should be tailored to the individual patient.

<H2>Target Audience

These guidelines are intended for use by all healthcare providers involved in nutrition support of the home patient receiving PN, primarily physicians, nurses, dietitians, and pharmacists. These guidelines may also be helpful to patients and their caregivers to assist them in the selection of a CVAD.

<H1>Literature Search Methodology

The PubMed/MEDLINE databases were searched through September 9, 2017, for relevant citations. To be included in our search results, citations had to be indexed in the “Catheters” and “Humans” MeSH folders as well as either the "Parenteral Nutrition, Home" or “Home infusion therapy” MesH folders. Then, the non-MEDLINE PubMed database was searched for any citation containing at least 1 text-based term from each of the following 2 groups of terms. Group 1: “Parenteral,” “HPN,” “TPN,” “Home PN,” “Home Health Care,” “HHC,” “home infusion.” Group 2: “catheter,” “Hickman,” “port,” “pic,” “PICC,” “tunnel,” “lock,” “vascular access device,” “flush.” Finally, to capture citations which may have been miscataloged by MEDLINE indexers, this same text-based strategy was restricted to terms found in the title or abstract of the citation and to the publication types “observational study,” “clinical trial,” “meta-analysis,” and “validation study” and used to re-search the MEDLINE database.

<H1>Results

In total, this search strategy yielded 564 citations. The MEDLINE database accounted for 350 citations, and the PubMed/non-MEDLINE database accounted for 214. The abstract for each citation abstract was reviewed to determine if it was 1) a randomized clinical trial, meta-analysis, or cohort study, 2) conducted in adults (>18 years), and 3) an intervention or exposure studied that included HPN. Studies meeting these 3 criteria were downloaded for further investigation to determine if they contained data that could answer 1 or more of the 6 specific questions that are addressed in these guidelines. Relevant outcome data included the type of catheter material, lumen number and type (tunneled, implanted, or peripherally inserted central catheter [PICC]) as they related to infection and mechanical complications, flush solutions used for maintenance (eg, heparin, saline), and the impact of antimicrobial and/or ethanol locks as a method for salvaging infected CVADs. If these criteria were met, the data were abstracted from the article, analyzed, and included in the guidelines. Articles were excluded if they did not meet inclusion criteria or contain data that would address at least 1 of the 6 guideline questions.

<H1>Introduction

HPN therapy requires patients to have a CVAD. Data obtained from ASPEN’s National Patient Registry for Nutrition Care (Sustain) found the duration of HPN therapy varies from 3 months–34 years for adults.[2] The appropriate CVAD that will accommodate these variable time intervals is essential to minimize complications and frequent access changes. Additionally, prior to selection of the CVAD, the contents of the HPN solution and patient and

caregiver preference as well as the ability to care for and monitor for complications all need to be considered. The CVADs used for HPN infusion include implanted infusion venous access devices (VADs), PICCs, and tunneled catheters,[3] each with unique risks (Table 3). The most common complications for HPN therapy are CVAD mechanical complications and central line–associated blood stream infections (CLABSIs). During the early years of HPN, removal of the CVAD was advocated for mechanical problems, such as clotting due to improper flushing when patency could not be resolved as well as for CLABSI. Treatment following CVAD removal for CLABSI was typically followed by the administration of several days of intravenous antibiotics. Re-insertion of the CVAD was only considered once the infection was resolved.

The expansive duration of HPN (ranging from months–decades) has shifted the focus of care to salvaging rather than removing the CVAD. Salvaging a long-term catheter is defined as trying to save or keep the catheter in place while treating mechanical or infectious complications. These can range from mechanical repair of a broken tunneled catheter to a full course of IV antibiotics to treat a catheter infection. This salvaging is beneficial to the patient as every CVAD insertion limits the number of remaining viable veins that can be used to reinsert a new CVAD in the future. Infusion of concentrated antibiotics sensitive to the offending organisms into the CVAD lumen was one of the first alternatives used to avoid venous access removal. To limit risks of antibiotic resistance and systemic toxic effects, the CDC Catheter Guidelines recommend prophylactic antibiotic lock solutions only in patients with long-term CVADs who have a history of multiple CLABSIs despite optimal maximum adherence to aseptic technique.[4] However, antibiotics may not adequately infiltrate the biofilm, a substance that allows microbial colonization along CVAD surfaces when in situ. This led to the treatment of CLABSI with concentrated ethanol as it has the ability to penetrate the biofilm and is bactericidal as well as fungicidal.[5] These properties have led many clinicians to use ethanol for treatment as well as prophylaxis in HPN populations.

The goals of HPN care are to 1) teach patients to become independent in their care, 2) keep patients in their home, and 3) maintain their quality of life by avoiding hospitalizations or unnecessary resource utilization needed to treat CVAD complications. To achieve these goals, clinicians must be knowledgeable in regard to the best CVAD on the market and the most effective treatment options that minimize risk of mechanical or infectious complications. Therefore, the recommendations provided in this guideline are tailored to address these issues and provide a science-based starting point for individualized HPN therapy.

Question 1: Does the type of CVAD (tunneled, implanted, or PICC) influence CLABSI rates? (See Table 4.)

Recommendations 1. Based on observational studies and expert consensus, we suggest tunneled CVADs should be selected for adult patients anticipated to require long-term daily PN infusions. If the duration of HPN is uncertain or of short duration (ie, <31 days), PICCs may be used.[6]

Quality of Evidence: Low

GRADE Recommendation: Weak

Rationale 1: No randomized controlled trials were found that addressed this question. Nine observational studies were found that compared CLABSI and types of CVAD.[7-13] An observational study of severely ill cancer patients compared CLABSI rates in tunneled, implanted, or PICC VADs, and found no significant difference between the groups even though implanted ports had a longer dwell time.[7] Severity of illness was not controlled for and may have been a factor contributing to the non-significant differences among the catheter groups.

Four studies compared CLABSI rates in patients with tunneled vs implanted CVADs (not PICC).[8-10,12] Three reported significantly higher rates of infections in patients with implanted CVADs.[8-10] Two of these studies[8,9] noted a higher proportion of cancer patients with implanted catheters compared with tunneled catheters, suggesting the higher infection rates observed may be due to the underlying disease, immunosuppression, and/or the use of implanted CVADs. Buchman et al[10] found higher rates of infections for implanted CVADs in a cohort of patients that predominantly had intestinal failure as their primary diagnosis rather than cancer. In a small case-series study of 6 severely ill cancer patients that first received a tunneled CVAD followed by an implanted CVAD, a higher rate of infection was reported in patients with tunneled CVADs.[12] Due to the very small sample size and sampling on the dependent variable, it is difficult to draw any conclusion from this study.

In addition to Cotogni et al,[7] 3 other studies compared CLABSI rates in tunneled vs PICC CVADs.[11,13,14] Christenson and associates and Bech and associates appeared to analyze the same dataset of Danish HPN patients, and while different questions were asked, similar results were found. Christensen et al[14] reported higher CLABSI rates for PICC compared with tunneled CVADs and a shorter time to first infection (84 ± 94 days vs 297 ± 387 days; $P < .05$). After controlling for environmental factors, Bech et al[11] reported identical time to first infection (83.91 ± 93.8 vs 297.2 ± 386.9 days; $P <. 001$) that was more

significant. Toure and associates[13] found higher rates of infections for the tunneled vs PICC CVADs; however, shorter median time to first infection occurred in the PICC group (60 vs 134 days; *P* = .008). Patients in the tunneled group received HPN prior to entry in the study; thus, this "greater unaccounted for exposure time" likely biased these results. Additionally, almost a third of patients in both groups were receiving taurolidine citrate locks, suggesting some or all were at higher risk of infection.

Ross et al[15] described CLABSI rates in 1046 HPN patients from a national cohort of patients in the United States of which 13.2% were <18 years of age. They found patients with tunneled or implanted CVADs experienced higher infection rates (0.51 and 0.66/total PN days, respectively) than those with PICCs (0.41/total PN days). Children experienced a higher rate of infection compared with adults; however, their reported infection rates by catheter type include both children and adults, which precluded inclusion of this study in our analyses.

In summary, 8 studies comparing different CVAD types found lower infection rates in patients with tunneled CVADs compared with implanted or PICC CVADs, and when reported, longer time to first infection suggesting tunneled CVADs may be preferable for patients expected to require HPN over a long period of time. Only 1 study that included both adults and pediatric patients found PICCs to experience lower rates. The impact of the concomitant use of implanted CVADs used for HPN and chemotherapy remains unknown.

Question 2. Does the number of CVAD lumens influence CLABSI rates? (See Table 5.)

Recommendation 2. Based on 1 observational study and expert opinion, we suggest using the fewest number of lumens required for individual patient therapy.

Quality of Evidence: Very Low

GRADE Recommendation: Weak

Rationale 2: Both the CDC and INS recommend selection of CVADs with the fewest number of lumens. In our more narrow search of adult HPN patients, we found 1 retrospective observational study comparing the number of CVAD lumens for risk of CLABSI.[10] This study compared infection rates in HPN patients from 1 homecare provider in patients with single-lumen, double-lumen, and triple-lumen tunneled CVADs. Significantly lower CLABSI rates occurred in patients with a single-lumen CVAD, followed by the double lumen. Triple-lumen

CVADs had the highest CLABSI rate (0.31 vs 0.7 vs 0.87/1,000 CVAD days, respectively; *P* = .001).

In summary, insertion of a CVAD with the fewest number of lumens to accommodate the patient's clinical status reduces the number of manipulations required for flushing pre-HPN and post-HPN and medication administration. CVADs with fewer lumens reduce the number of opportunities for contamination, are more economical, and require less maintenance for patients and caregivers. Further, it is highly unlikely restricting the catheter to the fewest lumens needed to provide care will result in any increase in harm.

Question 3. Does the type of CVAD material influence CLABSI rates? (See Table 6.)

Recommendation 3. We cannot make a recommendation at this time regarding CVAD composition to minimize infection.

Quality of Evidence: Very Low

GRADE Recommendation: Further research is needed

Rationale 3: Per the information presented in the CDC guidelines, due to their surface irregularities, the type of VAD material plays an important role in the development of CLABSI. These irregularities are thought to heighten the ability of microorganisms to adhere and attach to the surface. VADs manufactured with silicone have been shown to have higher risks of CLABSI compared with polyurethane.[16] In our narrower search, including exclusively adult HPN patients, only 1 study compared the role of CVAD composition with CLABSI. No statistical significance was found in this prospective, non-randomized study of 40 silicone and 13 polyurethane CVADs in 42 patients.[17] Only CVADs manufactured with silicone and polyurethane were included in the study.

To summarize, different CVAD materials may be more susceptible to the development of fibrin sheaths and biofilms that form within the CVAD lumen and the CVAD itself. Tunneled and implanted ports are made of silicone, which may lend itself to increase infection rates compared with PICCS manufactured with polyurethane.

Question # 4: What is the best CVAD for minimizing mechanical complications? (See Table 7.)

Recommendation 4: Based upon 6 observational cohort studies,[7,9,12-14,17] the risk for mechanical complications does not differ by the type of CVAD. Therefore, the choice of CVAD should be selected based upon length of therapy, patient choice, and the ability of the patient/caregiver to care for the CVAD.

Quality of Evidence: Low

GRADE Recommendation: Low

Rationale 4: A number of factors related to the CVAD type, size, material, and placement technique are hypothesized to contribute to mechanical complications of CVADs in patients receiving HPN; however, investigations in this area are limited.

When comparing polyurethane vs silicone CVADs, Beau and colleagues[17] found no significant difference in catheter CVAD obstruction or thrombosis among patients with short bowel syndrome (SBS). Additionally, Toure et al[13] found no significant difference in the incidence of non-infectious CVAD complications/1000 patient days in patients with SBS or Crohn's disease receiving HPN via a PICC or tunneled CVAD. The first complication occurred later in patients with a tunneled CVAD; however, this difference was not significant (180.2 ± 154.7 days vs 118.1 ± 129.3 days; P = .09).

Guglielmi et al[9] compared the differences of HPN complications in 270 patients with and without cancer. Cancer patients received HPN via implanted ports; HPN was delivered via tunneled CVADs in the non-cancer participants. No significant difference in incidence rates of mechanical complications occurred between these groups (0.28 vs 0.91/1000 CVAD days; not significant). Christensen et al[14] also evaluated mechanical complications in intestinal failure (IF) patients requiring HPN through a PICC or tunneled CVAD. Unfortunately, the material, brand, and size of the PICCs used did not remain constant during the study (silicone 4F Groshong PICC vs 5F polyurethane PICC), limiting interpretation of the findings. Patients with type II IF more often received a PICC, whereas long-term HPN patients with type III IF received tunneled CVADs. The authors defined type II IF as patients who had a prolonged acute condition, metabolically unstable, requiring intravenous therapy over a limited period of time, and type II patients were those with a chronic condition, metabolically stable requiring PN over months to years. Mechanical complications leading to CVAD removal was significantly higher in the PICC group (0.60 vs 1.5; P = .0011).

Cotogni and colleagues[7] prospectively observed CVAD complications in cancer patients with 4 types of VADs (PICC, Hohn PICC, tunneled, and implanted ports). Mechanical complications were 0.8/1000 catheter days. The Hohn CVAD experienced a significantly higher rate of catheter dislocation than the tunneled or PICC. The Hohn catheter is infrequently used in HPN patients in the United States.

In summary, based on these 6 studies when mechanical complications did occur, it appears to be due to CVAD design. PICCs, without an internal anchoring design, such as the cuff found on tunneled catheters, may be at increased risk for dislodgement. Additionally, PICCs that are not sutured in place, often exit on the distal arm, and require dressing changes that are difficult to perform independently (compared with a tunneled catheter exiting the chest) may also lend themselves to be accidently becoming dislodged. Tunneled VADs would have increased rates of malfunction compared with implanted ports due to cracking of the VAD hub and weakening of the lumen from repeated VAD clamping during and after flushing.

Question 5: Should antimicrobial or ethanol locks be used vs standard care for treating or preventing CVAD infections? (See Table 8.)

Recommendation 5: Based upon 2 studies, ethanol and antimicrobial lock instillations should be considered when used to prevent recurrent infection. Tunneled CVADs instilled with concentrated vancomycin demonstrated a decrease in CLABSI in 1 study. One study showed that there was no difference in removing an infected CVAD vs using a concentrated antibiotic lock followed by ethanol locks for several days.

Quality of Evidence: Low

GRADE Recommendation: Weak

Rationale 5. The CDC recommends that prophylactic antimicrobial locks be used only for long-term VADs with repeated CLABSIs following an in-depth review to insure that aseptic techniques are being followed and adhered to. In this narrower literature search of adult HPN patients, no randomized trials in adult HPN patients assessed the impact of antimicrobial or ethanol locks to treat or use prophylactically to prevent CLABSI. Three observational studies explored this question.[18-20] Lawinski et al[20] retrospectively compared differences in outcome in HPN patients (N = 428) with CVAD removal vs those treated first with ethanol locks followed by antibiotic lock–therapy. Of the 331 episodes of CLABSI, the

majority (231 of the CVADs) were automatically removed for specific criteria (eg, colonization with fungi or specific bacterial strain which were resistant to most antimicrobials, etc) without using a lock therapy. Of the 100 CVADs that remained in situ, a 95% ethanol solution was instilled daily for 4 days, followed by an antibiotic lock solution which was selected based upon the patient's blood culture results. There were no differences in the recurrence of CLABSIs with the same organism between the 2 groups over a period of 120 days.

The use of a prophylaxis lock of either a highly concentrated antibiotic or a 70% ethanol solution was studied in 59 patients who experienced a total of 313 CLABSI episodes: 264 before and 49 following initiation of the lock solution.[19] There were statistically significant differences in the prelocking groups (10.97 $\pm$ 25.92 infections/1,000 CVAD days) and postlocking groups (1.09 $\pm$ 2.53 infections/1000 CVAD days) as well as for the CVADs that instilled vancomycin (11.59 days prelocking and 1.04 days postlocking/1000 CVAD days; $P < .001$).

John et al[18] also examined the impact of CLABSI-related hospital admission using a 70% ethanol lock solution in adult HPN patients before and after ethanol lock using a quasi-crossover study design. Overall, 31 patients experienced 273 CLABSI-related admissions prior to ethanol lock treatment (10.04/1000 CVAD days) compared with 47 CLABSI after ethanol lock (6.48/1000 CVAD days; $P = .005$). When data were adjusted to include only tunneled CVADs, a significant decrease in CLABSI from 10.1 to 2.9/1000 VAD days before and after ethanol lock use remained.

In summary, while few studies have demonstrated the benefits of ethanol and antimicrobial locks in the adult population, a larger body of research exists for the pediatric HPN population. This research has consistently reported decreased rates of CLABSI.[21-23] However, increased VAD breakage and thrombosis rates with the use of ethanol have also been cited with the use of silicone CVADs.[23-25] It should be noted that ethanol locks can only be used if the CVAD material is silicone because a 70% ethanol lock solution has the potential to weaken CVADs constructed of polyurethane.[26] The effect of different dwell times and frequency, as well as concentrations of ethanol, on VAD integrity all are areas that require further investigation. Antimicrobial lock solutions also present difficulties due to the potential to develop antimicrobial resistance as well as risks due to side effects and allergic reactions. Additionally, studies investigating antimicrobial locks differ on the medication used, dose, and CVAD dwell times.

Question #6: Should saline or heparin locks be used for CVAD maintenance?

Recommendation 6. No recommendations can be made as to which flush solution should be used to maintain patency for HPN CVADs due to the lack of studies.

Quality of Evidence: Very Low

GRADE Recommendation: Expert opinion

Rationale 6: No studies have examined the impact of flushing with normal saline vs heparinized saline to reduce intraluminal clotting for adult patients infusing HPN. Manufacturer guidelines are generally followed regarding the use and frequency of heparin flush in open-ended CVADs. For valved or closed-tip CVADs, manufacturers recommend normal saline flushes. Home infusion providers most often follow standards of practice developed by the Intravenous Nurses Society who recommend flushing CVADs before and after medication administration with preservative-free 0.9% sodium chloride, followed by either heparin 10 U/mL or preservative-free 0.9% sodium chloride. Manufacturer guidelines and the type of needleless connector used also guides the clinician in making an informed decision as to flushing.

Although there are no studies in adult HPN patients that evaluated the efficacy of various flush solutions a priori, the prospective study by Lyons et al of 90 homecare patients that included 7 HPN patients infusing various therapy types via a PICC were randomized into 3 different flushing protocols.[27] The flushing protocols compared were saline alone, saline with heparin 10 U/mL, and saline with heparin 100 U/mL. Results indicated that the saline-only group required additional home RN visits to assess for sluggishness/occlusions (32.1% compared with 15.6% for the 100 U/mL and 13.3% for the 10 U/mL; P = .150). This group also experienced the highest percentage of patients requiring tissue plasminogen activator (tPA) to restore PICC patency (25% vs 9.4% and 10% in the 100 U/mL and 10 U/mL, respectively; P = .160). Both of these results trended toward significance, likely reflecting the small sample sizes. The impact of additional home visits by a registered nurse and the use of tPA needs to be considered when evaluating the benefits of the type of flushing solution.

In summary, there is no strong evidence to support the use of heparin vs saline flush solutions to maintain CVAD patency. This challenges the homecare clinician to further study the use of saline flush solutions due to the increased cost to provide heparin flushes as well as the potential for the development of heparin-induced thrombocytopenia.

<H1>Summary

These guidelines are tailored to assist clinicians to use best practices in the selection and care of CVADs for the infusion of HPN solutions in the adult patient. Due to the absence of randomized control studies, our recommendations to answer these questions are based upon observational cohort studies and expert opinion. For all of our questions, the quality of evidence was either low or very low. It is our hope that this systematic search strategy, followed by meticulous data abstraction, will provide clinicians with the most current scientific evidence to integrate with their clinical expertise and enable them to optimize catheter care for their HPN patients and to underscore the need for research in the homecare population.

These recommendations serve only as a beginning point to stimulate interest in developing the next generation of studies to provide optimal care to our HPN population. We selected key questions, but are aware that these as well as other questions remain unanswered. It is clear that further multidisciplinary research is needed to continue the quest to decrease or eliminate complications for our HPN patients.

<RF>References

1. Druyan ME, Compher C, Boullata JI, et el; American Society for Parenteral and Enteral Nutrition Board of Directors. Clinical guidelines for the use of parenteral and enteral nutrition in adult and pediatric patients: applying the GRADE system to development of A.S.P.E.N. clinical guidelines. *JPEN J Parenter Enteral Nutr.* 2012;36(1):77-80.
2. Winkler MF, DiMaria-Ghalili RA, Guenter P, et al. Characteristics of a cohort of home parenteral nutrition patients at the time of enrollment in the Sustain registry. *JPEN J Parenter Enteral Nutr.* 2016;40(8):1140-1149.
3. Chopra V, Flanders SA, Saint S, et al. The Michigan Appropriateness Guide for Intravenous Catheters (MAGIC): results from a multispecialty panel using the RAND/UCLA appropriateness method. *Ann Intern Med.* 2015;163(6 suppl):S1-S40.
4. O'Grady NP, Alexander M, Burns LA, et al: Guidelines for the prevention of intravascular catheter-related infections. *Am J Infect Control.* 2011;39(4 suppl 1):S1-S34.
5. Chambers ST, Peddie B, Pithie A. Ethanol disinfection of plastic-adherent micro-organisms. *J Hosp Infect.* 2006;63(2):193-196.
6. Moureau N, Chopra V. Indications for peripheral, midline and central catheters: summary of the MAGIC recommendations. *Br J Nurs.* 2016;25(8):S15-S24.
7. Cotogni P, Pittiruti M, Barbero C, et al. Catheter-related complications in cancer patients on home parenteral nutrition: a prospective study of over 51,000 catheter days. *JPEN J Parenter Enteral Nutr.* 2013;37(3):375-383.

8. Santarpia L, Alfonsi L, Tiseo D, et al. Central venous catheter infections and antibiotic therapy during long-term home parenteral nutrition: an 11-year follow-up study. *JPEN J Parenter Enteral Nutr.* 2010;34(3):254-262.
9. Guglielmi FW, Regano N, Mazzuoli S, et al. Catheter-related complications in long-term home parenteral nutrition patients with chronic intestinal failure. *J Vasc Access.* 2012;13(4):490-497.
10. 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. *JPEN J Parenter Enteral Nutr.* 2014;38(6):744-749.
11. 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. *JPEN J Parenter Enteral Nutr.* 2016;40(7):989-994.
12. Gaggioti G, Orlandoni P, Boccoli G, Capomagi A, Talevi S, Ambrosi S. Percutaneous vs. totally implantable catheters in home parenteral nutrition. *Clin Nutr (Edinburgh, Scotland).* 1986;5(1):33-40.
13. Toure A, Duchamp A, Peraldi C, et al. A comparative study of peripherally-inserted and Broviac catheter complications in home parenteral nutrition patients. *Clin Nutr (Edinburgh, Scotland).* 2015;34(1):49-52.
14. Christensen LD, Holst M, Bech LF, et al. Comparison of complications associated with peripherally inserted central catheters and Hickman catheters in patients with intestinal failure receiving home parenteral nutrition. Six-year follow up study. *Clin Nutr (Edinburgh, Scotland).* 2016;35(4):912-917.
15. 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.
16. Mehall JR, Saltzman DA, Jackson RJ, Smith SD. Fibrin sheath enhances central venous catheter infection. *Crit Care Med.* 2002;30(4):908-912.
17. Beau P, Matrat S. A comparative study of polyurethane and silicone cuffed-catheters in long-term home total parenteral nutrition patients. *Clin Nutr (Edinburgh, Scotland).* 1999;18(3):175-177.
18. John BK, Khan MA, Speerhas R, et al. Ethanol lock therapy in reducing catheter-related bloodstream infections in adult home parenteral nutrition patients: results of a retrospective study. *JPEN J Parenter Enteral Nutr.* 2012;36(5):603-610.
19. Davidson JB, Edakkanambeth Varayil J, Okano A, et al. Prevention of subsequent catheter-related bloodstream infection using catheter locks in high-risk patients receiving home parenteral nutrition. *JPEN J Parenter Enteral Nutr.* 2017;41(4):685-690.
20. Lawinski M, Majewska K, Gradowski L, Foltyn I, Singer P: A comparison of two methods of treatment for catheter-related bloodstream infections in patients on home parenteral nutrition. *Clin Nutr (Edinburgh, Scotland).* 2015;34(5):918-922.
21. Pieroni KP, Nespor C, Poole RL, Kerner JA Jr, Berquist WE. Echinocandin and ethanol lock therapy treatment of fungal catheter infections. *Pediatr Infect Dis J.* 2013;32(3):289-291.
22. Wales PW, Kosar C, Carricato M, de Silva N, Lang K, Avitzur Y. Ethanol lock therapy to reduce the incidence of catheter-related bloodstream infections in home parenteral nutrition patients with intestinal failure: preliminary experience. *J Pediatr Surg.* 2011;46(5):951-956.
23. Cober MP, Kovacevich DS, Teitelbaum DH. Ethanol-lock therapy for the prevention of central venous access device infections in pediatric patients with intestinal failure. *JPEN J Parenter Enteral Nutr.* 2011;35(1):67-73.

24. Abu-El-Haija M, Schultz J, Rahhal RM. Effects of 70% ethanol locks on rates of central line infection, thrombosis, breakage, and replacement in pediatric intestinal failure. *J Pediatr Gastroenterol Nutr.* 2014;58(6):703-708.
25. Meckmongkol TT, Costanzo C, Ciullo S, Prasad R, Arthur LG. Hidden morbidity of ethanol lock therapy. *Pediatr Surg Int.* 2018;34(1):71-74.
26. Crnich CJ, Halfmann JA, Crone WC, Maki DG. The effects of prolonged ethanol exposure on the mechanical properties of polyurethane and silicone catheters used for intravascular access. *Infect Control Hosp Epidemiol.* 2005;26(8):708-714.
27. Lyons MG, Phalen AG. A randomized controlled comparison of flushing protocols in home care patients with peripherally inserted central catheters. *J Infus Nurs.* 2014;37(4):270-281.
28. Worthington P, Balint J, Bechtold M, et al. When is parenteral nutrition appropriate? *JPEN J Parenter Enteral Nutr.* 2017;41(3):324-377.

Table 1. Guidelines for the Selection and Care of Central Venous Access Devices for Adult Home Parenteral Nutrition Administration.

Questions and Recommendations	Ev
Q1. Does the type of CVAD (tunneled, implanted, or PICC) influence CLABSI rates? **R1. Based on observational studies and expert consensus, we suggest tunneled CVADs should be selected for adult patients anticipated to require long-term daily PN infusions.** **If the duration of HPN is uncertain or of short duration (<30 days), PICCs may be used.**	Qu GI
Q2. Does the number of CVAD lumens impact CLABSI rates? **R2. Based on 1 observational study and expert opinion, we suggest using the fewest number of lumens required for individual patient therapy.**	Qu GI
Q3. Does the type of CVAD material influence CLABSI rates? **R3. We cannot make a recommendation at this time regarding CVAD composition to minimize infection.**	Qu GI ne
Q4. What is the best CVAD for minimizing mechanical complications? **R4. Based upon observational cohort studies, the risk for mechanical complications does not differ by the type of CVAD** **R4. The choice of CVAD should be selected based upon length of therapy, patient choice, and the ability of the patient/caregiver to care for the CVAD.**	Qu GI
Q5. Should antimicrobial/ethanol locks be used versus standard care for treating or preventing CVAD infections? **R5. No recommendation can be made at this time.**	Qu GI
Q6. Should saline or heparin locks be used for CVAD maintenance? **R6. No recommendations can be made as to which flush solution should be used to**	Qu

maintain patency for HPN CVADs due to the lack of studies.	GI

CLABSI, central line–associated blood stream infection; CVAD, central venous access device; GRADE, Grading of Recommendations, Assessment, Development and Evaluation; HPN, home parenteral nutrition; PICC, peripherally inserted central catheter; PN, parenteral nutrition.

Table 2: Language for Guidelines Recommendations.

Quality of Evidence	Weighing Risks Versus Benefits	Grading of Recommendations, Assessment, Development and Evaluation Recommendations	Clinical Guideline Statement
High to very low	Net benefits outweigh harms	Strong	We recommend
High to very low	Tradeoffs for patient are important	Weak	We suggest
High to very low	Uncertain tradeoffs	Further research needed	We cannot make a recommendation at this time.

Table 3: Types of Central Vascular Access Devices for HPN.

Type	Dwell Time	Therapeutic Applications	PN Considerations
PICCs	Maximum dwell time is unknown.	Suitable for acute care and short-term and medium-term PN for adults and pediatric patients	Associated with an increased risk for deep vein thrombosis, limiting use for indefinite PN therapy and situations where vessel preservation is a priority. Antecubital location of exit site hinders self-care and activity. Clothing may not always cover

			insertion site, potentially having a negative impact on body image; may be easily removed when infected or PN is no longer needed.
Tunneled CVADs (Hickman, Broviac, Hohn types)	3 months–years	Suitable for long-term PN; the presence of a cuff within the tunnel inhibits microbial migration and decreases risk of dislodgement.	No restrictions on upper extremity activity; position on chest facilitates self-care; VAD can be easily hidden under clothing.
Implanted ports	6 months–years	Primarily intended for low-frequency, intermittent access. Associated with lowest risk for CLABSI due to reduced manipulation. The presence of an indwelling needle to continuous or frequent access offsets the reduced infection benefit.	Suitable for PN in selected circumstances; motivated patients can learn access procedures; body image remains intact; requires no local site care when device is not accessed. PN may increase risk for CLABSI and occlusion in children with cancer.

Adapted with permission from the American Society for Parenteral and Enteral Nutrition.[28]

CLABSI, central line–associated blood stream infection; CVAD, central venous access device; HPN, home parenteral nutrition; PICC, peripherally inserted central catheter; PN, parenteral nutrition; VAD, venous access device.

Table 4: Question 1: Does the type of CVAD (tunneled, implanted, or PICC) influence CLABSI rates?

Rules for tables: Within each question, studies are listed in chronologic order with the newest studies placed first. When there was >1 study in a given year, studies were placed in alphabetic order according to the author's last name.

Reference	Study Design	Study Aim(s)	Population, Setting, N	Results/Outcor
Christensen et al[14]	Retrospective cohort	Compared complication rates of tunneled CVADs and PICCs in 1 Danish Center	136 adult HPN patients Total of 295 CVADs; 169 tunneled CVADs and 126 PICCs	CLABSI 0.57/10 catheter days in tunneled CVAD compared with PICC group (*P* = Local infection in PICC group v tunneled CVAD vs 0.24/1,000 C days, *P* = .000) Mean time to fi CLABSI higher i tunneled CVAD PICCs (297 ± 38 versus 84 ± 94 < .05)
Bech et al[11]	Retrospective cohort	Investigated whether environmental risk factors influenced the time to first CVAD-related infection	Adult HPN patients Total of 295 CVADs in 136 patients	Incidence of infections/1000 days was signifi increased in the group (1.43 ± 0 compared with 0.390 in the tu CVAD group Mean number to first infectio significantly de in the PICC grou the tunneled CV group (297.21 ± 386.91 vs 83.91

				93.754, respect Environmental the number of days per week, colectomy with smoking, if a homecare nurs managed the C care, and an ele C-reactive prot time of insertio not statistically significant amo 2 groups Mean CLABSI incidence signif increased in the tunneled CVAD if the CVAD wa managed by a homecare nurs compared with who were not (0.68 vs 0.56 ± 0 1000 CVAD day Time to first inf decreased CLAB the PICC group factor of 2.47 w additional infus day/week.
Toure et al[13]	Prospective cohort	A comparative study of peripherally inserted and tunneled CVAD complications	196 adult HPN patients 133 tunneled CVADs and 71 PICCs	CLABSI rate tunneled CVA 1.87/1000 CVA and 1.05 for PI Median num days to first complication v (16–674) for t CVADs and 6

				125) days for P
Buchman et al[10]	Retrospective cohort	Determined the risk factors for CLABSI in HPN patients.	Adult (N = 125) and pediatric (N = 18) HPN patients Total of 331 CVADs; 268 were tunneled and 63 implanted ports	CLABSI sign higher in implanted por than in the t group (0.66 0.32/1000 CVA respectively. CLABSI sign higher in adult triple-lumen (0.87/1000 CV for triple lum for double lum 0.31 for single l
Cotogni et al[7]	Prospective, observational	Investigated CVAD complications in cancer patients with 4 types of VADs (PICC, Hohn, tunneled CVAD, implanted ports)	254 adult HPN patients 289 CVADs; 65 PICCs, 107 Hohns, 45 tunneled CVADs, 72 implanted ports	No statistical differences bet the 4 types of C for local infecti CLABSI/1000 CV days or /1000 H days Multivariate an demonstrated CLABSI rate significantly lov when compare Hohn and tunn CVADs and for implanted port compared with and tunneled C
Guglielmi et al[9]	Prospective cohort	Described the long-term HPN frequency of complications both in adult cancer and non-cancer patients	270 adult HPN patients 139 patients with a cancer diagnosis and 131 without cancer	Incidence of se cancer patients 0.71/1000 CVA who had implan ports inserted compared with non-cancer pat who had tunne

				CVADs Local skin infec were 0.03/1000 days in the tun CVAD non-canc group, and 0.01 CVAD days in th cancer implante group
Santarpia et al[8]	Retrospective, cohort	CLABSI in oncology vs non-oncology patients, CLABSI by type of CVAD (totally implanted vs partially implanted tunneled CVAD)	Adult HPN patients (N = 296) 156 totally implanted ports and 140 partially implanted CVADs	Infection rates significantly lov partially implan tunneled CVAD compared with implanted port
Gaggioti et al[12]	Retrospective HPN crossover	Compared implanted ports and tunneled silicone CVADs	6 adult HPN patients; All 6 previously had a silicone tunneled CVAD and changed to an implanted port	Tunneled CVAD rate was 3.3/10 days compared 0.9/1000 CVAD the implanted p

CLABSI, central line–associated blood stream infection; CVAD, central venous access device; HPN, home parenteral nutrition; IV, intravenous; PICC, peripherally inserted central catheter; VAD, venous access device; vs, versus.

Table 5. Question #2: Does the number of CVAD lumens impact CLABSI rates?

Reference	Study Design	Study Aim(s)	Population, Setting, N	Results/Outcome	Comments
Buchman et al[10]	Retrospective cohort	Determined the risk factors for CLABSI in HPN patients.	Adult (N = 125) and pediatric (N = 18) HPN patients Total of 331 CVADs; 268 of which were tunneled and 63 implanted ports	CLABSI significantly higher in the implanted port group than in the tunneled group (0.66 and 0.32/ 1000 CVAD days, respectively CLABSI significantly higher in adults with a triple-lumen CVADs (0.87/1000 CVAD days; 0.7 for double lumens and 0.31 for single lumens)	Pediatric population data was included but the groups were compared separately for adults versus children.

CLABSI, central line–associated blood stream infection; CVAD, central venous access device; HPN, home parenteral nutrition.

Table 6: Question #3: Does the type of CVAD material influence CLABSI rate?

Reference	Study Design	Study Aim(s)	Population, Setting, N	Results/Outcome	Comments
Beau et al[17]	Cohort, prospective	Compared experience of long-term complications with polyurethane	Adult HPN patients N = 53 CVADs in 42	There were no obstructions reported in the polyurethane	Years of recruitment varied between the

	(LeaderCuff/Vygon) and silicone (Lifevac/Vygon) tunneled, cuffed CVADs	patients	group and 0.05/patient year of HPN in the silicone group Dislodgement and thrombosis/patient year of HPN not statistically significant Fracture and hub dysfunction higher in the polyurethane group (0.5/patient year of HPN) than the silicone group (0.03/patient year of HPN)	2 groups. Practice may have changed between 1991–1998. More patients in the silicone CVAD group (N = 31) as well as CVADs (N =40) compared with the polyurethane group with 11 patients and 13 CVADs. Measurement done per patient year of HPN.

CLABSI, central line–associated blood stream infection; CVAD, central venous access device; HPN, home parenteral nutrition.

Table 7: Question #4: What is the best CVAD for minimizing mechanical complications?

Reference	Study Design	Study Aim(s)	Population, Setting, N	Results/Outcor
Christensen et al[14]	Retrospective cohort	Compared complication rates of tunneled CVADs and PICCs in 1 Danish Center	136 adult HPN patients Total of 295 CVADs; 169 tunneled CVADs and 126 PICCs	If removal was a mechanical (CVAD fell out out by r occlusion, bro other defects removal was (1.5 compare 0.6/1000 CVAD
Toure et al[13]	Prospective cohort	Compared rates of complications associated with peripherally inserted and tunneled CVADs	196 adult HPN patients 133 tunneled CVADs and 71 PICCs	There was no difference in no infection complications between PICC a tunneled CVAD catheters The mean num catheter days t infection complications v significant betw the 2 CVAD typ
Cotogni et al[7]	Prospective, observational	Investigated CVAD complications in cancer patients with 4 types of VADs (PICC, Hohn, tunneled CVADs, implanted ports)	254 adult HPN patients 289 CVADs; 65 PICCs, 107 Hohns, 45 tunneled CVADs, 72 implanted ports	There were no differences in mechanical complications/ CVAD days or / HPN days betw 4 CVADs There were 16 catheter disloc for the Hohn, compared with the tunneled ar

				PICCs
Guglielmi et al[9]	Prospective cohort	Described the long-term HPN frequency of complications both in adult cancer and non-cancer patients	270 adult HPN patients 139 patients with a cancer diagnosis and 131 without cancer	Overall, incider mechanical complications h in the non-canc patients with tu CVADs compare the cancer pati with implanted (0.91 and 0.82/ patient days, respectively)
Beau et al[17]	Cohort, prospective	Compared experience of long-term complications with polyurethane (LeaderCuff/Vygon) and silicone (Lifevac/Vygon) tunneled, cuffed CVADs	Adult HPN patients N = 53 CVADs in 42 patients	There were no obstructions re in the polyureth group and 0.05 patient year of the silicone gro Dislodgement a thrombosis/pat year of HPN wa statistically sign Fracture and hu dysfunction we higher in the polyurethane (0.5/patient ye HPN) than the s group (0.03/pa year of HPN)
Gaggioti et al[12]	Retrospective HPN crossover	Compared implanted ports and tunneled silicone CVADs	6 adult HPN patients; All 6 previously had a silicone tunneled CVAD and changed to	There were no the numbe tunneled CVAD occlusions occu

an implanted port 1 patient

CLABSI, central line–associated blood stream infection; CVAD, central venous access device; HPN, home parenteral nutrition; IV, intravenous; PICC, peripherally inserted central catheter; VAD, venous access device.

Table 8: Question #5: Should antimicrobial/ethanol locks be used for treating or preventing CVAD infections?

Reference	Study Design	Study Aim(s)	Population, Setting, N	Results/Outcome	Comments
Davidson et al[19]	Retrospective, cohort	Rate of CLABSI before and after antibiotic or ethanol lock	59 eligible patients 51 patients instilled their CVADs with antibiotic lock 8 patients instilled their CVADs with ethanol lock	Total of 313 CLABSI; before the use of a locking solution, the CLABSI rate was 10.97 ± 25.92/1000 CVAD days; following locking 1.09 ± 2.53/1000 CVAD days ($P < .001$) For patients who instilled with ethanol lock: CLABSI rate was 4.18/1000 CVAD days before locking and 0.47/1000 CVAD days after locking For patients who instilled antimicrobial lock CLABSI rate was 12.03/1000 CVAD days and 1.19 after locking Pre-vancomycin locks: rate was 11.59/1000 CVAD days, and post-vancomycin locks decreased to 1.04/1000 CVAD days	No statistical significance in the reduction of VAD infection rates when antimicrobial locking was used compared with ethanol locking. Decision as to which lock solution used was made depending upon clinical evaluation and was not controlled. Patients could have used both an antimicrobial and ethanol lock, thus being included in both groups. The type of lock reported and use in the analyses was the lock that the patient was using the

					majority of the time. The appropriate antimicrobial lock solution was based upon previous CLABSI episodes and the general incidence, not on an organism obtained from a blood culture. No mention as to how often a patient was instilling the lock technique. Small sample sizes in both groups.
Lawinski et al[20]	Retrospective, cohort	Compare antimicrobial (according to blood culture results) with 95% ethanol lock therapy versus CVAD removal	428 adult patients receiving HPN	181 patients developed 352 episodes of CLABSI 48 patients treated with ethanol/ antimicrobial lock versus 133 treated with CVAD removal and replacement of a new catheter Median numbers to CVAD infection complication after treatment 1053 ± 748	No statistical differences in the 2 groups. CLABSI not defined. Ethanol lock used for 4 days followed by antimicrobial lock for 4 days; HPN restarted after last

			days in antimicrobial /ethanol group and 952 ± 709 days in the CVAD removal/replacement group Average time of catheter use after a CLABSI to next episode of infection: 436 ± 436 days antimicrobial /ethanol group; 468 ± 411 days CVAD removal/replacement group Re-infection in tunneled CVADs after treatment for CLABSI: 431 ± 437 days in antimicrobial /ethanol group; 565 ± 443 CVAD removal/replacement group	antimicrobial lock and if asymptomatic and repeat blood culture negative, patient sent home.
John et al[18]	Retrospective, cohort Patients served as their own control	Investigated the efficacy of ethanol lock installation (3 mL of 70% ethanol followed by 10 mL normal saline) in reducing the incidence of CLABSIs	31 adult HPN patients	273 CLABSI-related admissions pre-ethanol lock and 47 admissions post-ethanol lock/1000 CVAD days CLABSI hospital admits /1000 catheter days was 10.04 before and 6.48 after ethanol (*P* = .005) Incidence of CLABSIs decreased from 3.53 before to 1.65 after	Small sample size. No reported side effects or complications from ethanol lock. Only patients with silicone catheters received ethanol lock. In the pre-ethanol lock population, 16

		ethanol lock/1000 CVAD days (P = 0.011) Number of CVAD/1000 CVAD days was 6.14 before and 3.72 after ethanol (P = .15) Number of CVADs removed for CLABSI decreased from 3.31 to 1.93 before and after ethanol for lock, P = .058 Adjusted data for only tunneled CVADs demonstrated a reduction in CLABSI readmissions from 10.1 pre-ethanol lock to 2.9/1000 CVAD days post-ethanol lock (P < .001)	patients had PICCs for at least some of the infusion days. Number of catheter days in prelock group was 27,210 and 7201 in tunneled group with ethanol lock. Ethanol lock started on existing CVADs in which the presence of a biofilm could affect results.

CLABSI, central line–associated blood stream infection; CVAD, central venous access device; HPN, home parenteral nutrition; IV, intravenous; VAD, venous access device.