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A Descriptive Study of the Risk Factors Associated with Catheter-Related Bloodstream Infections in the Home Parenteral Nutrition Population

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Abstract

Background—Home parenteral nutrition (HPN) is increasingly used for nutrition support after patients are discharged from the hospital. Catheter-related bloodstream infections (CR-BSI) are a common and potentially fatal complication of HPN. The risk factors for development of CR-BSI in the outpatient setting are poorly understood.

Methods—We conducted an observational, retrospective study of 225 patients discharged from Barnes-Jewish Hospital on HPN between January 1, 2007, and December 31, 2009. HPN complications were defined as any cause that led to either premature discontinuation of HPN therapy or catheter replacement. CR-BSI events were identified by provider documentation. We calculated the overall complication rate and the complication rate specifically due to CR-BSI. Backward stepwise Cox regression analyses were used to assess for independent predictors of catheter-related complications.

Results—In total, 111 of 225 patients (49%) developed complications while receiving HPN (incidence = 5.06 episodes/1000 catheter days). Sixty-eight of 225 patients (30%) required catheter removal for CR-BSI (incidence = 3.10 episodes/1000 catheter days). Independent predictors of line removal specifically due to infection included anticoagulant use, ulcer or open wound, and Medicare or Medicaid insurance. The following risk factors were associated with

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catheter-associated complications and/or CR-BSI: the presence of ulcers, the use of systemic anticoagulants, public insurance (Medicare or Medicaid), and patient age. Independent predictors of line removal for any complication included age and anticoagulant use.

Conclusion—Catheter-related complications were extremely common in patients receiving HPN. Healthcare providers caring for individuals who require home TPN should be aware of risk factors for complications.

Keywords

HPN; catheter; complication; infection; survival

Clinical Relevancy Statement

Clinicians who manage patients receiving home parenteral nutrition (HPN) must understand the risk factors associated with catheter-related bloodstream infections (CR-BSI) and other catheter-related complications. Our article describes new risk factors for both CR-BSI and overall catheter-related complications in the HPN population. Therefore, our findings are both essential and clinically relevant to providers caring for patients receiving HPN.

Background

The expansion of home health and nutrition support agencies now makes home parenteral nutrition (HPN) a practical alternative to a prolonged inpatient hospitalization.[1] HPN provides improved quality of life with lower cost than inpatient parenteral nutrition (PN).[2–5] HPN has been purported to offer similar rehabilitation and complication outcomes compared with inpatient PN.[6–9]

HPN is not risk-free and can have significant mechanical (eg, line occlusion), infectious, and metabolic complications (eg, hyperglycemia, hypertriglyceridemia), which may occur in as many as 5% of patients.[10] Fifteen percent of HPN-associated complications are directly attributable to the use of central venous catheters.[10] The rate of catheter-related bloodstream infections (CR-BSI) is unclear, with estimates varying between 0.9 and 18.3 episodes per 1000 line days for patients receiving HPN.[11,12] It is clear that further investigation is warranted.

Although multiple risk factors for CR-BSI have been identified in patients receiving HPN,[13] many of these risk factors were poorly defined and identified only in small studies. In fact, Dreesen et al[13] identified that only 2 out of 39 published HPN articles were considered good quality by objective criteria. In general, the time frames, sample sizes, case definitions, and source of diagnoses were inadequate in most studies. Therefore, the rates of CR-BSIs and other clinically relevant complications (ie, death, deep venous thrombosis, and phlebitis) in the HPN population are unclear.

Guidelines on PN management have primarily focused on hygiene, catheter placement, and other modifiable attributes but have not examined sociodemographics, comorbid conditions, and clinical characteristics that may be associated with adverse outcomes.[14] Therefore, the goals of this study were to determine the frequency of infections and other complications

among patients receiving HPN and to determine which risk factors were associated with a greater occurrence of complications in patients receiving HPN.

Materials and Methods

Study Design

Retrospective data were collected on 225 patients who were discharged on PN via central venous catheters at Barnes-Jewish Hospital (BJH), a 1250-bed academic medical center in the Midwestern United States, between January 1, 2007, and December 31, 2009. Information on patients receiving HPN was obtained from the PN dietitians' database. Relevant clinical and sociodemographic data were abstracted from electronic medical records. Medical records were reviewed for complications until October 31, 2010.

Patient Selection

All patients who received PN at BJH during our study period were required to have a consult from one of the PN dietitians. Each consult by one of the PN dietitians included patient education on aseptic technique and hand hygiene for PN. Subsequently, every consult was entered into a paper database. The database was cross-referenced with a prospectively collected inpatient electronic research database and confirmed via electronic medical records to evaluate for missing or erroneous observations.

Predictor Variable Definitions

Comorbid conditions were determined based on chart documentation or laboratory records. Anticoagulant therapy was defined as therapy with one of the following agents: heparin or low molecular-weight heparin (excluding deep venous thrombosis prophylaxis), argatroban, bivalirudin, or warfarin on hospital discharge. Cancer was defined as any active malignancy within the past year, excluding basal and squamous cell carcinoma of the skin. Chemotherapy was defined as any systemic chemotherapeutic agent administered within the past 30 days before censoring. Ulcer/wound was defined as any chart documentation of skin or mucosal breakdown, including gastrointestinal tract fistulas. Immunosuppression was defined as any systemic non-chemotherapeutic agent that deliberately reduces the action of the immune system. Agents included but were not limited to azathioprine, prednisone at a dosage of > 10 mg/day, tumor necrosis factor inhibitors, monoclonal antibodies (ie, rituximab), methotrexate, cyclophosphamide, or mycophenolate mofetil. Renal dysfunction was defined as a serum creatinine value > 1.5 mg/dL at the time of discharge. Tobacco, alcohol, and drug use were defined as current use by chart review. Reasons for PN were based on chart documentation. Bowel fistula was defined as any abnormal anatomic connection between the intestinal lumen and the lumen of another body structure. Bowel obstruction was defined as the presence of a small or large bowel obstruction in the medical record. Bowel surgery was defined as any unspecified postoperative complication of abdominal surgery where the clinician requested PN.

Outcome Variable Definitions

HPN complications were defined as any cause that led to either premature discontinuation of HPN therapy or catheter replacement, excluding contaminated blood cultures (defined

below). Examples of HPN complications included catheter dysfunction (eg, leakage or intraluminal dysfunction), catheter-associated deep venous thrombosis, and death. CR-BSI was defined as at least 1 positive blood culture of a known human pathogen in the absence of any other documented source of infection or clinical diagnosis of blood stream infection without positive blood cultures. Blood cultures that were positive for normal skin flora were considered contaminants if they were noted as such in the medical records by the treating physician. The primary end point was defined as the development of the first infection or complication requiring catheter removal.

Loss to Follow-up

Patients who were lost to follow-up were evaluated in 2 ways. First, we used the social security death index to identify patients who died while receiving HPN. We conservatively designated these cases as complications because we were unable to determine if the patient's death was directly related to HPN therapy. Second, we searched the electronic medical records of neighboring hospitals in the 12-hospital Barnes-Jewish-Christian network, the largest employer in St Louis, Missouri (the geographic area for our study). If we were still unable to clearly identify any complications, then we defined these patients as having no infections and used the last known PN administration date to calculate the duration of therapy.

Outpatient Complications Attributed to Inpatient Care

Catheter complications that occurred within 48 hours after discharge were considered unrelated to outpatient HPN care and were excluded to prevent confounding from inpatient care.

Outcomes

The primary outcome was HPN complication or CR-BSI at 365 days postcatheter placement for PN.

Catheter In Situ Time

Catheter in situ time was calculated from the time of placement for PN until removal for CR-BSI, complication, or censoring. All patients were censored at 365 days post-central venous catheter insertion for PN. We decided to censor the infection and complication data at 365 days because we were concerned that lines lasting longer than 1 year without complications were more likely to be subject to bias from undocumented catheter complications.

Statistical Analysis

Descriptive statistics were calculated and reported as mean ± standard deviation (or median with interquartile range where appropriate) for continuous variables and frequency (percentage) for categorical variables. Comparisons of sociodemographic and clinical variables across complication and infection status were tested by χ^2 for categorical variables and Student t test (or Mann-Whitney U where appropriate) for continuous variables.

Potential confounding characteristics with a P value < .10 (rather than $P < .05$, to allow for negative confounding) in bivariate analysis were entered as covariates into a backward stepwise Cox regression (entry/retention level; $P < .15$) in accordance with the principles of hierarchical model building. The proportional hazards hypothesis was verified before the variables were included. All tests for significance were 2-sided, and P values of ≤ .05 were considered statistically significant. All statistical analyses were conducted using SPSS for Windows, version 20.0 (SPSS).

The Washington University institutional review board approved the study protocol.

Results

Sample Characteristics

Sociodemographic and clinical characteristics are presented in Table 1. Of the 225 patients included in the study, a majority of the patients were female (n = 140; 62%) and Caucasian (n = 189; 84%). The most common catheter types used were non-tunneled lines (eg, Hohn catheter, n = 104; 46%) and peripherally inserted central venous catheter (PICC) (n = 76; 34%), with tunneled central line (eg, Hickman, n = 20; 9%) catheters being the least used type of catheter.

Catheters remained in place for a total of 21,934 line days. The median time that catheters remained in situ was 57 (IQR = 73) days. The age range of patients in the study was 22–93 years with a median age of 54 (IQR = 19) years. The most common comorbidities among patients were cancer (n = 92; 41%), hypertension (n = 85; 38%), and the presence of ulcers or wounds (n = 70; 31%). Indications for HPN are listed in Table 2. The most common primary indications for HPN were the presence of a bowel fistula (n = 59; 26%), bowel surgery (n = 43; 19%), and the presence of a bowel obstruction (n = 43; 19%).

Catheter Complications

Complications were reported in 111 (49%) of the study participants (incidence = 5.06 episodes per 1000 line days). The most common complications were CR-BSI (n = 68; 61%) and death (n = 31; 28%), whereas catheter-related dysfunction, deep venous thrombosis, and accidental catheter displacement comprised the remaining complications (n = 12; 11%). All of the measured potential risk factors stratified by complication are summarized in Table 1. Several risk factors were more common in patients who developed catheter complications than in those who did not, including patient age ($P < .01$), public insurance ($P = .03$), hypertension ($P = .03$), anticoagulation ($P = .05$), and line placement at BJH ($P = .02$).

We identified 2 risk factors that were independently associated with catheter complications after controlling for other variables with Cox proportional hazards modeling (Table 3). First, older patients were more likely to develop catheter complications. Specifically, for each additional year in patient age, there was a 2% increase in the hazard of premature catheter removal. Second, patients receiving anticoagulant therapy were at a 1.64 times increased hazard of line complications compared with those who were not receiving anticoagulant therapy.

Catheter-Related Infections

Infections occurred in 68 patients (30%) (incidence = 3.10 episodes per 1000 line days). Our cohort included CR-BSI from gram positive bacteria (n = 49; 57%), gram negative bacteria (n = 19; 22%), and fungal organisms (n = 14; 16%). Only 4 CR-BSI (5%) were due to unknown or unspecified organisms. The most commonly isolated organisms were *Staphylococcus epidermidis* (n = 21; 24%), *Candida* species (n = 14; 16%), and *Klebsiella* species (n = 9; 11%) (Table 4).

Several predictor variables were more common in patients who developed CR-BSI than in those who did not, including public insurance ($P = .01$), ulcers or open wounds ($P = .01$), and anticoagulation ($P = .01$). Patients with CR-BSI also had shorter in situ catheter durations (days to catheter removal: 61 vs 48; $P = .01$). It is surprising that underlying malignancies were less common in patients who developed CR-BSI than in patients who did not ($P = .01$).

We identified 3 risk factors that were independently associated with CR-BSI after controlling for other variables with Cox proportional hazards modeling (Table 3). First, patients receiving anticoagulant therapy were at a 2.22 times increased hazard of developing CR-BSI compared with those individuals not receiving anticoagulant therapy ($P = .01$). Second, patients with ulcers or other open wounds were at a 2.03 times increased hazard of developing CR-BSI compared with those patients without ulcers or other open wounds ($P \leq .01$). Finally, individuals on public health insurance (Medicare or Medicaid) were at a 1.71 times increased hazard of developing CR-BSI compared with those patients not on public insurance ($P = .03$).

Discussion

The comprehensive collection of patient information, large cohort size, and rigorous statistical analysis of this study greatly contributed to the HPN literature by allowing us to identify several novel findings, including new risk factors associated with catheter-related complications and CR-BSI following HPN administration. First, we identified a higher rate of CR-BSI caused by fungal rather than bacterial pathogens. Second, we identified novel risk factors for both catheter-related complications and CR-BSI. Patient age and anticoagulation were associated with a higher risk of catheter-related complications; public insurance status, anticoagulant therapy, and the presence of ulcers were all associated with a higher risk of CR-BSI.

Although we found an overall rate of complications caused by infections similar to that reported in previous studies,[15–17] the microbiology of the organisms involved greatly differed from that previously reported. We identified far fewer cases than expected of CR-BSI from typical skin flora, such as *Staphylococci*, compared to prior reports.[18] More concerning, we found a rate of fungal infections that was twice that reported in a recent systematic review (16% vs 8%).[19] We believe that there are 2 possible reasons for the higher rate of fungal infections. First, we believe that the increased number of fungal isolates obtained in our study compared with previous studies is part of a wider epidemiological trend seen with candidemia in the United States and worldwide.[20] Second, the CR-BSI rate

due to bacterial pathogens has been decreasing, possibly because of an increasing focus on aseptic techniques, maximal sterile barriers, and use of chlorhexidine skin preparations during central venous catheter placement.[18]

Overall, we found a similar rate of catheter-related complications to that previously reported.[11,12,15–17] Age and anticoagulant treatment were independently associated with catheter-related complications after adjustment for other risk factors. It is interesting that these findings were in contrast to previously reported literature. Dreesen et al[13] identified 3 studies that found no correlation between age and HPN complications and 2 additional studies that found an increased risk of complications in younger patients. It is possible that their findings were influenced by confounding variables, as they failed to use multivariable regression models. The cause of the increase in HPN complications with age is not clear but may be related to age-related factors such as impaired vision and impaired dexterity, potentially increasing the risk of a breakdown in sterile technique when accessing central catheter. Age itself may also be a factor, as other groups have reported that age may be a risk factor for other infections such as surgical site infections.[21] Alternatively, the higher observed complication rate in older individuals could be related to our decision to include death as a complication. Older patients may be more likely to have serious underlying conditions that could increase their risk of death. Indeed, death was more common in patients older than 50 years ($P < .05$).

We were also surprised to see anticoagulation identified as a risk factor for catheter complications. Studies have shown that therapeutic levels of anticoagulant therapy are effective at reducing the frequency of thrombotic complications and catheter occlusions and improving catheter survival.[22,23] This finding might be explained by the retrospective nature of this study. The reason and duration of anticoagulation were not collected in our study, and it is possible that some of the patients who received anticoagulation had been recently diagnosed with a thrombotic or vascular disease. Therefore, the presence of active anticoagulation may simply be a marker for people with underlying prothrombotic tendencies, as suggested by other authors.[24]

Anticoagulant therapy may be given as prophylaxis against the thrombosis in central venous catheters.[25] As discussed above, we suspect that anticoagulant therapy may have been a marker for patients with an established thrombus or at markedly increased risk of thrombosis, which could increase the risk for thrombus-associated infection. Alternatively, it has been proposed that anticoagulant therapy may be responsible for subclinical bleeding and the formation of hematomas, resulting in an increased risk of developing an infection.[26]

We also found that risk factors for CR-BSI included public insurance status (eg, Medicare or Medicaid), anticoagulant therapy, and ulcers. These risk factors have not been previously identified as risk factors for catheter complications in patients receiving HPN.[12,13,19,27,28] Patients on public insurance tend to be older and/or have lower socioeconomic status (SES) based on eligibility criteria.[29,30] As our multivariable regression model adjusts for age, it is likely that lower SES in these patients contributes to an increased risk of infection. This idea is supported by Chang et al,[31] who reported that HPN patients receiving social welfare were at an increased likelihood of developing line infections.

Skin ulcers and open wounds, which are known risk factors for bloodstream infections,[32,33] were also associated with an increased hazard of CR-BSIs in our study. However, how these lesions contributed to CR-BSI is unclear. It is plausible that skin ulcers and other open skin wounds allow for the direct transmission of micro-organisms to the catheter via hub contamination or the migration of pathogens along the external surface of the catheter.[34]

Our study has several strengths including multivariable regression analysis, large sample size, and extensive follow-up through a network of community hospitals. However, there are also some clear limitations. First, the single-center, retrospective nature of the study created inherent issues with loss to follow-up. It is probable that some patients developed complications or infections but did not receive care at this or one of the affiliate institutions; thus, this information was not documented in the patient's electronic medical records housed at BJH. Therefore, individuals who were lost to follow-up may have biased the estimated infection and complication rates for our study. Second, complications that did not require line replacements were impossible to ascertain with this study design. Third, some patients with a history of recurrent CR-BSI on HPN may have received antimicrobial therapy with the catheter left in place. Without access to home health nursing records, we are unable to adjust for this factor. However, reports from the dietitians who follow these patients regularly while they are hospital inpatients suggested that this number would be quite low. Fourth, we used clinician judgment rather than strict Centers for Disease Control National Healthcare Safety Network (NHSN) diagnostic criteria to determine the presence of CR-BSI.[25] Thus, our study may have overestimated the infection rate, particularly when coagulase-negative *staphylococci* were isolated. However, for ease of surveillance purposes, the identification of line infections using a clinical definition of CR-BSI was used as an accepted methodology.[25] In addition, we accepted clinician assessment of CR-BSI rather than using central line associated bloodstream infection (CLSBSI) because we felt that chart review alone would be inadequate to assess for CLSBSI criteria such as fevers, especially if the fevers were to occur prior to hospitalization. Furthermore, the NHSN makes use of this clinical definition in their surveillance network.[25] Fifth, we designated death as a complication of HPN. The deaths of many individuals in our cohort were almost certainly unrelated to HPN. However, our study design limits our ability to determine the cause of death in all cases. Therefore, some of our conclusions are subject to confounding. However, the most likely risk factor associated with death, active malignancy, was not identified as a risk factor for complications following HPN. Sixth, it is possible that some of our identified risk factors such as ulcer/wounds and anticoagulation were in reality markers for secondary bacteremias and other risk factors such as deep venous thrombosis, as described above. Seventh, due to the retrospective nature of our study, it was impossible to ascertain patient hygiene practices at the time of discharge; thus, we were unable to measure hand hygiene patterns in our retrospective HPN cohort—a known risk factor for CR-BSI. Finally, the presence of malignancy could confound our assessment of the relationship between anticoagulation and catheter complications. For example, malignancy is a well-established risk factor for both deep venous thrombi and death. However, this association was controlled for in our multivariable regression analysis. In addition, a large percentage of individuals in our cohort received anticoagulation for short-bowel syndrome.

Conclusion

In conclusion, approximately half of our cohort had complications, of which infections comprised the vast majority of catheter-related complications. Our cohort had a higher frequency of fungal pathogens, which may suggest a changing epidemiology of CR-BSI in the HPN population. In addition, we identified a number of risk factors for both catheter complications and CR-BSI. At this time, it is unclear if some risk factors such as anticoagulant therapy and the presence of a wound or ulcer play a pathogenic role in CR-BSI or are merely markers of increased risk. Clinicians should be aware of the factors that are associated with HPN complications to guide clinical care. Furthermore, studies should longitudinally examine the issue of complications in patients receiving HPN.

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Table 1

Sociodemographic and Clinical Characteristics of Line Complications and Line Infections.

		Complication[a]			CR-BSI[a]		
	All Patients (N = 225)	Complication (N = 111)	No Complication (N = 114)		Infection (N = 68)	No Infection (N = 157)	
Characteristic	**No. (%)**	**No. (%)**	**No. (%)**	***P* Value**	**No. (%)**	**No. (%)**	***P* Value**
Age, median (IQR), y	54 (18.50)	58 (19)	51 (17)	< .01	56 (17.75)	53 (19.00)	.28
BMI	24 (8)	23 (7)	25 (9)	.53	24 (8)	25 (8)	.61
Female	140 (62)	74 (67)	66 (58)	.18	45 (66)	95 (61)	.42
Race							
Non-Caucasian[b]	36 (16)	21 (19)	15 (13)	.24	14 (21)	22 (14)	.22
Caucasian	189 (84)	90 (81)	99 (97)	—	54 (79)	135 (86)	—
Length of time from line placement to line removal, median (IQR), d[c]	57 (73)	51 (56)	66 (103)	.01	48 (56)	61 (86)	.08
Employment status							
Unemployed	73 (32)	44 (40)	29 (25)	.06	26 (38)	47 (30)	.45
Employed	54 (24)	22 (20)	32 (28)	—	14 (21)	40 (26)	—
Not specified	98 (44)	45 (41)	53 (47)	—	28 (41)	70 (45)	—
Insurance status							
Medicare/Medicaid	97 (43)	56 (51)	41 (36)	.03	39 (57)	58 (37)	.01
Private	128 (57)	55 (50)	73 (64)	—	29 (43)	99 (63)	—
Comorbidities							
CAD	22 (10)	14 (13)	8 (7)	.16	8 (12)	14 (9)	.51
CVA	8 (4)	6 (5)	2 (2)	.17	4 (6)	4 (3)	.25
HTN	85 (38)	50 (45)	35 (31)	.03	31 (46)	54 (34)	.11
HLP	41 (18)	25 (23)	16 (14)	.10	14 (21)	27 (17)	.55
AC	34 (15)	22 (20)	12 (11)	.05	17 (25)	17 (11)	.01
COPD	14 (6)	10 (10)	4 (4)	.09	5 (7)	9 (6)	.76
DM	40 (18)	24 (22)	16 (14)	.14	13 (19)	27 (17)	.73
Cancer[d]	92 (41)	49 (44)	43 (38)	.33	19 (28)	73 (47)	.01
Chemotherapy	29 (13)	18 (16)	11 (10)	.14	5 (7)	24 (15)	.10

Characteristic	All Patients (N = 225)	Complication[a]			CR-BSI[a]		
		Complication (N = 111)	No Complication (N = 114)		Infection (N = 68)	No Infection (N = 157)	
	No. (%)	No. (%)	No. (%)	*P* Value	No. (%)	No. (%)	*P* Value
Connective tissue disorder	10 (4)	6 (5)	4 (4)	.54	5 (7)	5 (3)	.17
IBD[e]	36 (16)	14 (13)	22 (19)	.17	12 (18)	24 (15)	.66
Renal dysfunction[f]	11 (5)	4 (4)	7 (6)	.38	2 (3)	9 (6)	.37
Ulcer/open wound	70 (31)	40 (36)	30 (26)	.12	30 (44)	40 (26)	.01
Immunosuppression	22 (10)	8 (7)	14 (12)	.20	5 (7)	17 (11)	.42
Tobacco use	45 (20)	22 (20)	23 (20)	.95	13 (19)	32 (20)	.83
Alcohol use	41 (18)	22 (20)	19 (17)	.54	15 (22)	26 (17)	.33
Drug use	10 (4)	7 (6)	3 (3)	.21	3 (4)	7 (5)	1.00
Hospital status							
Surgical	169 (75)	82 (74)	87 (76)	.67	52 (77)	117 (75)	.76
Nonsurgical	56 (25)	29 (26)	27 (24)	—	16 (24)	40 (26)	—
Home health agency							
BJC home infusion	186 (83)	94 (85)	92 (81)	.43	59 (87)	127 (81)	.29
Other health agency	39 (17)	17 (15)	22 (19)	—	9 (13)	30 (19)	—
Catheter type							
Hohn	104 (46)	51 (46)	53 (47)	.66	31 (46)	73 (47)	.39
PICC	76 (34)	28 (25)	48 (42)	—	20 (29)	56 (36)	—
Hickman	20 (9)	14 (13)	6 (5)	—	13 (19)	7 (5)	—
Port	23 (10)	16 (14)	7 (6)	—	3 (4)	20 (13)	—
Other	2 (1)	2 (2)	0 (0)	—	1 (2)	1 (1)	—
PICC catheter	76 (34)	28 (25)	48 (42)	.01	20 (29)	56 (36)	.36
Line placement by BJH	203 (90)	95 (86)	108 (95)	.02	63 (93)	140 (89)	.42

AC, anticoagulant; BJC, Barnes-Jewish-Christian; BJH, Barnes-Jewish Hospital; BMI, body mass index; CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; CR-BSI, catheter-related bloodstream infections; CVA, cerebrovascular accident; DM, diabetes mellitus; HLP, hyperlipidemia; HTN, hypertension; IBD, inflammatory bowel disease; IQR, interquartile range; LTAC, long-term acute care facility; PICC, peripherally inserted central venous catheter; SNF, skilled nursing facility.

[a]Event censored at 365 days post-line insertion date.

[b]Non-Caucasian: Asian/Pacific Islander = 1; Hispanic = 1; other = 1.

[c]Time to event censored at 365 days post-line insertion date.

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[d] Cancer: solid tumor or hematological malignancy.

[e] IBD: Crohn's disease or ulcerative colitis.

[f] Renal dysfunction: chronic kidney disease defined as a creatinine level of 1.5 mg/dL or greater or as a patient on dialysis.

Table 2

Primary Indication for Parental Nutrition.

Indicator	All Patients (n = 225), No. (%)
Bowel fistula	59 (26)
Bowel surgery	43 (19)
Small bowel obstruction	43 (19)
Pancreatitis	18 (8)
Cancer	16 (8)
Inflammatory bowel disease[a]	15 (7)
Short gut syndrome	11 (5)
Weight loss	10 (4)
Other[b]	10 (4)

[a] IBD: Crohn's disease or ulcerative colitis.

[b] Other: nausea/vomiting, postoperative ileus, ischemic bowel, preoperative.

Table 3

Independent Predictors for 365-Day Central Line-Associated Bloodstream Infection or Line Complication Using Cox Proportional Hazards Modeling.[a]

	Complications			CR-BSI		
Predictor[b]	**HR**	**95% Confidence Interval**	***P* Value**	**HR**	**95% Confidence Interval**	***P* Value**
Anticoagulant	1.64	1.03–2.62	.04	2.22	1.28–3.85	.01
Ulcer	—	—	—	2.03	1.25–3.30	< .01
Age	1.02	1.01–1.04	< .01	—	—	—
Insurance Medicare/Medicaid	—	—	—	1.71	1.05–2.77	.03

CR-BSI, catheter-related bloodstream infections. HR, hazard ratio.

[a] Variables included in the models were all variables with a *P* value < .10 in Table 1.

[b] Backward stepwise model entry = .05, stay = .05.

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Table 4

Micro-organisms Isolated from CR-BSI Episodes, Censored at 365 Days Post-Catheter Insertion.

Organism	Number Isolates[a] (n = 68), No. (%)
Staphylococcus epidermidis	21 (30)
Candida species	14 (20)
Klebsiella species	9 (13)
Enterococcus faecalis	8 (12)
Staphylococcus aureus (methicillin-sensitive)	6 (9)
Staphylococcus aureus (methicillin-resistant)	6 (9)
Other coagulase negative *Staphylococcus*	5 (7)
Other[b]	17 (25)

CR-BSI, catheter-related bloodstream infections.

[a]Multiple micro-organisms were isolated from some patients.

[b]Other: *Citrobacter* species, *Enterobacter* species, *Enterococcus* species, *Escherichia coli, Neisseria* species, *Proteus* species, *Streptococcus* species, unknown isolate.