

Gram-negative bloodstream infections in hematopoietic stem cell transplant patients: The roles of needleless device use, bathing practices, and catheter care

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Background: Between August 1 and October 30, 1998 (outbreak period), an increased incidence of central venous catheter (CVC)-associated gram-negative bacterial bloodstream infection (GN-BSI) was detected in hematopoietic stem cell transplantation (HSCT) candidates and recipients in an outpatient HSCT unit. The objectives of the present study were to determine strategies for controlling the outbreak and identify risk factors for GN-BSI.

Methods: Two case-control studies, an assessment of infection control practices, microbiologic studies, and water quality analysis were conducted. A case was defined as any outpatient with a CVC and a primary GN-BSI during the outbreak period.

Results: All of the 31 case patients identified had needleless intravenous (IV) access devices. Independent risk factors for CVC-associated GN-BSI were self-administered IV infusion (odds ratio [OR] = 6.2; $P = .02$), lower frequency of needleless device changes (OR = 15.2; $P = .03$), and more frequent baths (OR = 1.4; $P = .05$). Interventions included increased frequency of needleless device change, recommending showers rather than baths, and use of CVC protection during showering/bathing. After these interventions, the CVC-associated GN-BSI rate declined to below the preoutbreak period rate (2.1/1000 vs 0.3/1000 CVC-days; $P < .01$).

Conclusions: This study demonstrated an increased risk of CVC-associated GN-BSIs related to self-IV infusion, bathing habits, and frequency of needleless device change. Infection control practices associated with the use of needleless devices may expose susceptible patients to increased risk for BSI.

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Over the last decade, health care delivery has become increasingly relocated from inpatient to outpatient and home settings.¹ Hematopoietic stem cell transplantation (HSCT) is frequently performed to treat neoplastic diseases, among others, and involves the infusion of hematopoietic stem cells from a donor into a patient who has received chemotherapy. Patients undergoing HSCT require continuous intravenous (IV) access before, during, and after transplantation; thus, all of these patients have a long-term central venous catheter (CVC) inserted before the procedure. New technologies for HSCT allow for earlier patient hospital discharge; thus, many patients receive most of their care as outpatients and perform their own IV infusion therapy (ie, peripheral blood stem cells, hydrating fluids, nutritional supplements, medications, immunoglobulin, and blood products) at home.^{2,3} Regardless of the setting, patients who have undergone HSCT, who are at increased risk of acquiring infections, require frequent access of their CVC for IV infusion therapy.⁴

To decrease the risk of occupationally acquired needlestick injuries and minimize transmission of

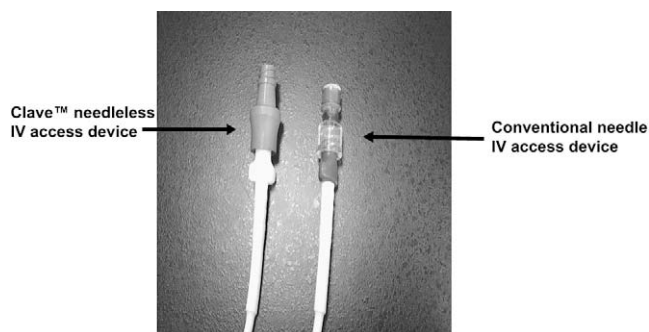


Fig 1. The Clave needleless IV access device and a conventional needle IV access device attached to a Hickman catheter.

bloodborne pathogens, safer IV delivery systems, such as needleless IV access devices (ND), have been developed.^{5,6} Although the use of NDs has become widespread, they have been associated with an increased risk of bloodstream infection (BSI).⁷⁻¹³

In August 1998, infection control personnel at the Fred Hutchinson Cancer Research Center (FHCRC) and Swedish Medical Center (SMC) in Seattle, WA, detected an increasing number of BSIs caused by various gram-negative (GN) bacteria in HSCT outpatients. Each of the HSCT patients had a long-term, tunneled, double-lumen CVC—specifically, a Hickman catheter (Bard Access Systems, Salt Lake City, UT). There appeared to be a temporal association between the increase in GN-BSIs and the introduction of the Clave (ICU Medical, San Clemente, CA) in the outpatient department on July 20, 1998. The Clave is a 1-piece needleless connector with a leuc-lock mechanical valve that is placed on the end of the CVC lumen, through which blood is drawn and fluids are infused (Fig 1).

When episodes of GN-BSI continued to occur despite several interventions, on October 27, 1998, the Centers for Disease Control and Prevention (CDC) and the Washington State Health Department were invited to assist in an investigation. In this report, we describe the investigation, risk factors for GN-BSI, and interventions that were successful in controlling the outbreak.

METHODS

Setting

Approximately 400 transplantations are performed annually at the FHCRC's HSCT center, with a daily outpatient census of 150 patients.

Case definition and ascertainment

A case patient was defined as any HSCT candidate or recipient in the FHCRC's outpatient department with a

CVC who had a primary GN-BSI, as defined by the CDC,¹⁴ between August 1 and October 30, 1998 (outbreak period). If a patient had 1 or more GN-BSI episodes during the outbreak period, the second was considered a separate episode if it occurred ≥ 14 days after the first episode and after complete clinical recovery from the first episode. The preoutbreak period was defined as January 1 to July 31, 1998. Infection control and microbiology records were used to identify the case patients.

CVC-days and BSI rates

CVC insertion and removal dates were used to calculate the total number of CVC-days for each patient. For those patients in whom CVC insertion and removal dates were not available, CVC-days were estimated to be the same as patient-days, because all patients had CVCs inserted within 10 days of admission.

CVC-associated GN-BSI rates per 1000 CVC-days were calculated for each month by dividing the number of patients with CVC-associated GN-BSI by the total number of CVC-days in the FHCRC's outpatient department during each month and multiplying by 1000.

CVC-associated GN-BSI rates were calculated for the preoutbreak, outbreak, and postintervention (November 1, 1998 to December 31, 1999) periods. Mean HSCT outpatient CVC-associated GN-BSI rates during the summer months (July to September) were compared with those in the nonsummer months (October to June) for 1989 to 1997 and during the outbreak year.

Observational studies

Infection control practices and procedures were assessed by interviewing health care workers and observing their practices. Educational materials written for outpatients and classes on CVC care directed at patients and caregivers were reviewed and observed.

Case-control studies

Two case-control studies were conducted to identify risk factors for CVC-associated GN-BSI. Control patients were randomly selected from all HSCT patients in the outpatient department during the outbreak period. To be eligible, a control patient must have had an outpatient follow-up time or time elapsed since last inpatient discharge of ≥ 17 days (median time to BSI for case patients).

In the first case-control study, 1 control patient was selected for each case patient. To further assess CVC insertion and manipulation practices and patients' exposure to water at their homes, a second case-control study was performed, with 2 control patients selected for each case patient. The case patients included in the first case-control study were further evaluated by phone interview.

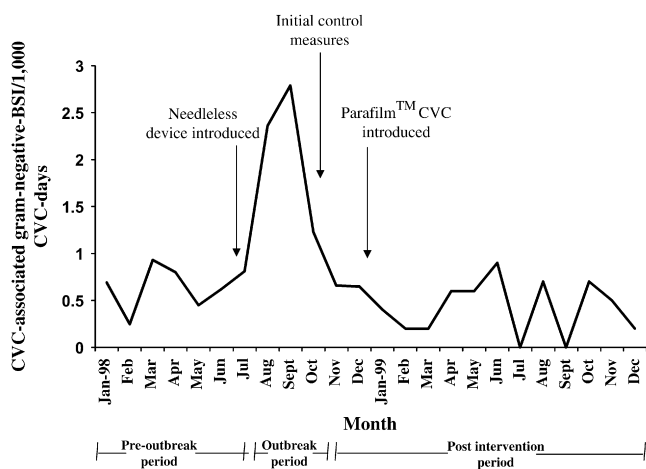


Fig 2. CVC-associated GN-BSI rates in HSCT outpatients at the FHCRC, January 1998 to December 1999.

Microbiologic studies

Clinical indications and protocols for blood culture collection were similar in the preoutbreak, outbreak, and postintervention periods. According to FHCRC guidelines, indications for blood culture collection include fever (temperature exceeding 38.3°C orally or 37.8°C axillary), chills (unrelated to amphotericin or blood product administration), and steroid administration ≥ 0.5 mg/kg/day.

All blood cultures were performed using the BACT ALERT automated blood culture system (bioMérieux, Durham, NC) and the Isolator quantitative blood culture system (Dupont, Wilmington, DE). Organisms were identified using the Vitek automated system (bioMérieux) or conventional biochemical tests. Antimicrobial susceptibility testing was performed using standardized disk diffusion or Vitek methods. Cultures were performed on a sample of prefilled flush syringes (Rocap, Niles, IL), and unused and used Hickman catheters and Clave NDs.

Water quality and atmospheric and water temperature evaluation

The Seattle Public Utilities' Water Quality Laboratory was consulted to evaluate water treatment procedures and identify any breaks in these procedures or water distribution in Seattle during the study periods. To assess the effect of seasonal variation of atmospheric and water temperature on CVC-associated GN-BSI rates, average monthly atmospheric temperature in the Seattle urban area from 1989 to 1998 and the temperature of the water distributed to the FHCRC in 1998 were obtained from the Western Regional Climate Center of the National Oceanic and Atmospheric Administration and the Water Quality Laboratory.

Bacterial counts in water

Mean monthly bacterial counts (colony-forming units [cfu]/mL) were compared in outbreak and preoutbreak periods and in summer (July to September) and nonsummer months for 1990 to 1998. The water samples analyzed were obtained from the open reservoir from which water is distributed to the FHCRC (*Pseudomonas* spp) and the distribution station from which water is supplied to the FHCRC (coliform count and heterotrophic plate count [HPC]).

Statistical analysis

Univariate analyses were performed using the CDC's Epi-Info 6.04b software.¹⁵ The χ^2 or Fisher's exact test and Wilcoxon's 2-sample test were used to analyze categorical and continuous variables, respectively. Odds ratios (ORs) and 95% confidence intervals (CI₉₅) were calculated. Poisson regression was used to determine trends in infection rates. Stepwise logistic multivariate analysis was performed using PC-SAS (SAS Institute, Chicago, IL),¹⁶ with variables found to be significantly associated with CVC-associated GN-BSI in univariate analysis ($P < .1$) included in the final model.

RESULTS

The HSCT outpatient CVC-associated GN-BSI rate was higher during the outbreak period than during the preoutbreak period (2.1 vs 0.7 per 1000 CVC-days; relative risk [RR] = 3.17; CI₉₅ = 1.81 to 5.56; $P < .01$) (Fig 2), during which 31 GN-BSI episodes were identified. The characteristics of the case patients varied (Table 1). All case patients had a Hickman CVC with a Clave ND attached to each lumen's distal end. At diagnosis, 22 patients (71%) were receiving IV fluids both at home and in the outpatient department, 7 (23%) were receiving IV fluids only at home, and 2 (7%) were receiving IV fluids only in the outpatient department. All of these patients lived in the same area as the FHCRC and thus likely received their tap water through the same distribution stations. Most often, the patient's spouse ($n = 14$; 45%) was the main caregiver, followed by a parent/in-law ($n = 10$; 32%), sister ($n = 3$; 10%), and the patient himself or herself ($n = 2$; 6%). Twelve patients (39%) had acute myeloid leukemia, 6 (19%) had chronic myeloid leukemia, 5 (16%) had a solid organ malignancy (ie, 3 breast cancer, 1 lung cancer, 1 neuroblastoma), 2 (6%) had multiple myeloma, 2 (6%) had acute lymphoid leukemia, 2 (6%) had aplastic anemia, 1 (3%) had myelodysplasia, and 1 (3%) had non-Hodgkin's lymphoma.

Twenty-four case patients had been hospitalized at the FHCRC before their GN-BSI episode. Six case patients

Table 1. Comparison of potential risk factors for CVC-associated GN-BSI, case-control study 1, FHCRC, August to October 1998

Potential risk factors	Case patients (n = 31)	Control patients (n = 31)	OR (CI ₉₅)	P
Categorical variables, n (%)				
Blood draws*	21 (68)	20 (64)	1.2 (0.3 to 3.8)	.8
Female gender	18 (58)	12 (39)	2.2 (0.7 to 7.0)	.1
Allograft type	22 (71)	25 (81)	0.6 (0.2 to 2.2)	.4
Graft-versus-host disease*	17 (55)	1 (5)	1 (0.3 to 3.1)	1.0
Immunosuppression*	18 (58)	23 (74)	0.5 (0.1 to 1.6)	.2
IV infusions at home	29 (94)	28 (90)	1.0 (0.1 to 11.3)	1.0
Only one caregiver	23 (74)	23 (74)	0.8 (0.2 to 3.1)	.8
Caucasian race	29 (93)	28 (90)	1.0 (0.1 to 11.3)	1.0
Receipt of:				
Chemotherapy*	19 (61)	24 (77)	0.5 (0.1 to 1.6)	.2
Granulocyte colony-stimulating factor*	3 (10)	3 (10)	1 (0.1 to 7.1)	1.0
IV antimicrobials*	7 (23)	5 (16)	1.5 (0.4 to 6.6)	.5
IV fluids*	21 (68)	19 (61)	1.3 (0.4 to 4.3)	.6
Steroids*	17 (55)	18 (58)	0.9 (0.3 to 2.7)	.8
Transfusions*	6 (19)	5 (16)	1.2 (0.3 to 5.6)	.7
Continuous variables, median (range)				
Age, years	46 (2 to 66)	40 (1 to 64)		.2
CVC duration, days	75 (6 to 555)	63 (1 to 789)		.5
Number of CVC breaks*	15 (6 to 45)	12 (6 to 36)		.3
Number of outpatient department visits/week	1 (1 to 3)	1 (1 to 3)		.1
Time after HSCT, days [†]	57 (2 to 343)	50 (37 to 853)		.9
Time after hospital discharge, days [‡]	17 (4 to 56)	20 (18 to 91)		.1
Time of outpatient follow-up, days	104 (28 to 511)	144 (67 to 270)		.1

*In the 72 hours before GN-BSI diagnosis.

[†]Information available for 51 patients (24 case patients and 27 control patients).[‡]Information available for 54 patients (24 case patients and 30 control patients).

(19.4%) experienced their GN-BSI episode before undergoing HSCT. Of the 25 case patients who experienced GN-BSI after HSCT, 17 (68%) had undergone an allogeneic HSCT (6 unmatched; 11 matched), 5 (20%) had undergone an autologous HSCT, 2 (8%) had received an allogeneic peripheral blood stem cell (PBSC) infusion, and 1 (4%) had undergone a syngeneic HSCT.

Ten case patients (32.5%) had polymicrobial bacteremia; 6 (19.2%) had a concomitant GN and gram-positive BSI. Twenty case patients (64.5%) were symptomatic at the time of CVC-associated GN-BSI, 10 (32%) were hospitalized, 13 (48%) underwent CVC removal after the diagnosis of BSI, and 3 (9.7%) died. Among the symptomatic patients, the most common symptom was fever (16 patients; 80%).

Observational studies

All outpatients had CVC breaks or manipulation by health care workers while in the outpatient department, and most also had CVC manipulation at home. IV lines were flushed with saline and heparinized saline solutions from single-use prefilled syringes after every blood draw or IV infusion. If the patient had no IV infusion or blood draw, then the CVC was routinely flushed once daily with heparinized saline. Patients were instructed to wash their hands vigorously

with soap and water before and after each CVC manipulation and to not wear gloves. The CVC entrance site was dressed with gauze and tape until healed, after which no dressing was used. Patients were allowed to shower or take baths according to their preference, and were instructed to remove the exit site dressing during bathing. Patients were instructed to avoid swimming pool or hot tub water exposure.

Case-control study 1

In the first case-control study, the case and control patients did not differ significantly (Table 1). The case patients had a higher median number of CVC breaks in the 72 hours preceding diagnosis of GN-BSI, although this difference was not statistically significant. The case patients also had a higher mean number of CVC breaks at home (11.3 [range, 6 to 26] vs 9.3 [range, 6 to 22]; $P = .35$).

Case-control study 2

In the second case-control study, despite repeated attempts, only 17 of the 31 case patients could be reached by phone, due to death ($n = 3$), residence out of the country ($n = 3$), or unavailable/incorrect/outdated phone number ($n = 8$). Self-IV infusion was significantly more common in the case patients (Table 2). Compared with patients taking showers only, those

Table 2. Comparison of potential risk factors for CVC-associated GN-BSI, case-control study 2, FHCRC, August to October 1998

Potential risk factors	Case patients (n = 17)	Control patients (n = 34)	OR (CI ₉₅)	P
Univariate analysis				
Categorical variables, n (%)				
Attended educational session	15 (88)	29 (85)	1.3 (0.2 to 11.2)	.8
Bathing practices				
Only bath	3 (18)	2 (6)	4.2 (0.4 to 44.3)	.1
Both bath/shower	5 (29)	7 (21)	2.0 (0.4 to 9.7)	.5
Only shower	9 (53)	25 (73)	Ref	–
Catheter protection before bathing	2 (12)	4 (12)	1.0 (0.1 to 7.7)	1.0
Handwashing before CVC handling*	16 (94)	32 (97)	0.5 (0 to 20.2)	.6
Infusion administration at home				
Self-IV infusion	13 (76)	11 (32)	7.1 (1.4 to 40.7)	< .01
Self-IV flushing	14 (82)	16 (47)	5.2 (1.1 to 28.6)	.02
Caregiver performing flushes and infusions	3 (18)	18 (53)	Ref	–
Type of drinking water				
Tap	9 (53)	14 (41)	1.6 (0.4 to 6.2)	.4
Bottled, filtered, distilled	8 (47)	20 (59)	Ref	–
Continuous variables, mean (range)				
Number of flushes/day	1.1 (1 to 3)	1.1 (1 to 3)	–	.1
Number of needleless device changes/week	2 (1 to 7)	2.4 (1 to 7)	–	.02
Number of baths/week	1.9 (0 to 7)	0.8 (0 to 7)	–	.09
Number of showers/week	4.8 (0 to 7)	6.3 (0 to 7)	–	.01
Multivariate analysis				
Self-administered IV infusion				
Yes	–	–	6.2	0.02
No	–	–	Ref	–
Frequency of needleless device changes/week				
Once	–	–	15.2	–
More than once	–	–	Ref	0.03
Number of baths/week	–	–	1.4	0.05

*Information available for 50 patients (17 case patients and 33 control patients).

patients who took baths only or who took both baths and showers were more likely to have had a CVC-associated GN-BSI (although this difference was not statistically significant). The case patients also had a significantly lower mean number of ND changes per week, as well as a lower mean number of showers, but a higher mean number of baths, taken per week.

In multivariate analysis, independent risk factors for CVC-associated GN-BSI were self versus caregiver administration of IV infusions through the CVC, lower frequency of ND changes, and higher number of baths, with each additional bath per week associated with increased risk (Table 2).

Microbiology studies

Overall, 52 GNB-BSI isolates were recovered from the case patients (Table 3). Ten (32%) case patients had a polymicrobial BSI, 7 with 3 organisms, 2 with 4 organisms, and 1 with 5 organisms identified in a single blood culture.

Water quality and temperature analysis

Water from 9 open reservoirs is chlorinated at water treatment plants before distribution to urban Seattle.

Weekly water quality control testing is performed at the treatment plant and sample distribution sites throughout the city. Unchlorinated water from the reservoirs is tested weekly for total coliform count, fecal coliform, *Pseudomonas* spp, algae, and HPC. Several sample distribution sites throughout the city also test finished water for HPC. US Environmental Protection Agency (EPA) regulations allow a maximum HPC load of 500 cfu/mL in distributed water; < 5% of the monthly samples were positive for total coliform. No violations of the guidelines governing the treatment and distribution of water to the FHCRC were detected, and bacterial counts were under the allowable limits. No supplemental water disinfection or testing is performed at FHCRC, except for dialysis and physical therapy. Routine testing of tap water is not performed. Compared with in the nonsummer months, the median average monthly ambient temperature in Seattle was higher in the summer months in 1989 to 1998 (19.4 vs 8.8°C; $P < .01$) and during the outbreak period in the summer of 1998 (25 vs 8°C; $P < .01$).

Analysis of bacterial counts in water

The mean monthly *Pseudomonas* spp. count in the reservoir was higher during the outbreak period

Table 3. Distribution of case patient CVC-associated BSI pathogens, FHCRC, August to October 1998

Organism identified in blood culture	Number (%) (n = 52)*
<i>Acinetobacter</i> spp	8 (15.4)
<i>Klebsiella</i> spp	7 (13.5)
<i>Enterobacter</i> spp	6 (11.5)
<i>Pseudomonas</i> spp	5 (10.6)
<i>Stenotrophomonas maltophilia</i>	5 (10.6)
<i>Escherichia coli</i>	4 (7.7)
<i>Citrobacter freundii</i>	2 (3.8)
<i>Agrobacterium radiobacter</i>	2 (3.8)
<i>Flavimonas oryzae</i>	1 (1.9)
<i>Serratia marcescens</i>	1 (1.9)
<i>Moraxella catarrhalis</i>	1 (1.9)
<i>Flavobacterium</i> spp [†]	1 (1.9)
<i>Streptococcus viridans</i> [†]	1 (1.9)
<i>Micrococcus</i> spp [†]	3 (5.8)
Coagulase-negative <i>Staphylococci</i> [†]	5 (10.6)

*Number of isolates cultured from 31 case patients.

[†]Organism identified in polymicrobial GN-BSI only.

compared with the preoutbreak period (15.8 vs 6.3 cfu/mL; $P < .21$), reaching its peak in August 1998 (mean, 32.5 cfu/mL). The mean coliform count in the water from the sample stand in the distribution system supplying the FHCRC was higher in the summer months than in the nonsummer months in 1990 to 1998 (0.057 vs 0.008 cfu/mL; $P < .01$). Similarly, HPC counts (10.6 vs 0.41 cfu/mL; $P < .01$) and noncoliform bacteria counts (13.78 vs 2.39 cfu/mL; $P < .01$) also were higher in the summer months during this period.

Comparison of CVC-associated GN-BSI rates in summer and nonsummer months

The median monthly CVC-associated GN-BSI rate in HSCT outpatients was higher during the summer months in January 1989 to December 1997 (1.2 vs 0.8/1000 CVC-days; $P < .02$). When the outbreak year (1998) is included in the analysis, the median GN-BSI rate was even higher in the summer months (1.4 vs 0.8/1000 CVC-days; $P < .01$). The median CVC-associated GN-BSI rate in HSCT outpatients was significantly higher in the summer months of 1998 than in the summer months of 1989 to 1997 (2.6 vs 1.2/1000 CVC-days; $P = .3$).

Control measures

On October 12, 1998, the "push-pull" method of flushing the line (ie, pushing and pulling the syringe several times before drawing blood from the CVC) was discontinued. Subsequently, the use of micropore tape around the connection between the distal end of the CVC and the Clave ND was discontinued. Despite these changes, BSIs continued to occur, albeit at a lower

incidence rate (1.2/1000 CVC-days in October vs 2.8/1000 CVC-days in September) (Fig 2).

After the investigation, based on our findings, on November 10 we made the following recommendations: (1) The frequency of ND changes should be at least twice a week; (2) NDs should be changed every time that blood is drawn in the outpatient department, except on days when multiple blood samples are drawn; (3) patients should go to the outpatient department for an ND change at least twice a week; and (4) patients should be encouraged to shower rather than bathe if physically able. Written educational materials for patients were revised to include information on the risk of infection associated with water exposure, including bathing, and frequency of ND changes. We recommended that educational sessions for patients and/or caregivers should be offered after every inpatient discharge, before initiating home infusion therapy.

After November 1998, the CVC-associated GN-BSI infection rate continued to drop (from 1.2 CVC-days in October to 0.7/1000 CVC-days in November), eventually reaching preoutbreak nonsummer month rates (Fig 2).

In December 1999, the FHCRC and SMC infection control team collaborated with nursing staff to develop a feasible and practical standardized method to protect the CVC ND connection from tap water during bathing (bath or shower). Parafilm "M" laboratory film (Pechiney Plastic Packaging, Chicago, IL) was stretched and wrapped securely around the CVC-ND connection before the bath or shower and removed afterward. Patients were discouraged from taking baths, but if they insisted on bathing, they were instructed to use Parafilm and to keep the CVC out of the water. After the introduction of Parafilm, the CVC-associated GN-BSI infection rate declined even further (0.7/1000 vs 0.47/1000 CVC-days; $P < .01$) (Fig 2).

DISCUSSION

Health care-associated BSIs have a high cost, attributable mortality, and excessive length of hospital stay in critically ill patients,^{2,17-19} particularly in patients undergoing HSCT. Since the early 1990s, a change in the spectrum of organisms causing nosocomial CVC-associated BSIs has been observed in immunocompromised patients, with increases in GN bacteria.^{4,20,21} Infection rates associated with tunneled catheters are lower than those reported for nontunneled CVCs.²¹ All of the patients in our investigation had a Hickman catheter. However, increased rates of BSI have been reported in home health care patients with tunneled CVCs with external ports,^{2,3,22} particularly associated with patients' bathing habits.¹² Catheter care, bathing, and other infection control practices

associated with CVCs are important determinants of BSI risk, and they may be even more important in the outpatient/home environment.

Hydrophilic GN bacteria and *Enterobacteriaceae* were the most commonly identified organisms in our outbreak. After intrinsic or extrinsic contamination of infusates was ruled out, this pattern of BSI in our outpatients suggested tap water as the potential source of infection.

At the time of the outbreak, 4 different NDs were commercially available: Clave, Safsite (Braun Medical, Bethlehem, PA), Interlink (Baxter, Deerfield, IL), and IVAC (IVAC Medical Systems, San Diego, CA). Various studies have demonstrated an increased risk of GN-BSI associated with the use of different NDs and infection control practices in outpatient and home^{8,9,12} or inpatient settings.^{10,11,13} Most of these ND-associated outbreaks have occurred in patients receiving home IV infusion therapy.^{2,22} Some have suggested that the increased BSI rates may reflect less-than-ideal infection control practices and lack of knowledge of appropriate use of NDs, rather than intrinsic problems with the devices themselves.^{8,10-12}

In home settings, a patient is more likely to receive intermittent flushes and infusions through the CVC and may be more frequently exposed to tap water. Bathing with no CVC protection may allow water-borne hydrophilic GN bacteria or *Enterobacteriaceae* to colonize the CVC-ND connection. Avoiding direct water contact with the CVC or changing the NDs more frequently would reduce the bacterial burden that can enter the bloodstream at the CVC access site.¹²

In our study, BSI risk could not be attributed to ND use itself, because all of the case and control patients had NDs in place. However, a temporal association was identified between introduction of the Clave ND and increased CVC-associated GN-BSIs. We believe that breaks in infection control practices, together with the use of NDs, helped create favorable conditions for GN-BSIs. Although some ND manufacturers have specific recommendations for frequency of ND changes, the optimal frequency of end cap or ND changes for each type of ND remains to be defined.

We hypothesize that environmental conditions may influence bacterial growth and concentrations in tap water. The initial decline in CVC-associated GN-BSI rates can be associated with the beginning of the fall season and declining mean monthly ambient temperature (from 17.2°C in September to 11.4°C in October 1998). Additional control measures instituted after November 10 may have played an important role in the further reduction of CVC-associated GN-BSIs (reaching 0.7/1000 CVC-days by November). It is clear that in addition to seasonal variation, the introduction of Parafilm and other interventions were effective in

successfully preventing future summer GN-BSI increases in 1999.

In the United States, the EPA oversees the microbial quality of community drinking, recreational, and tap water,²⁵ according to the American Waterworks Association's standard treatment protocols. Whether water quality standards for tap, drinkable, and recreational water provide sufficient protection for immunosuppressed patients is unknown.

Our study has demonstrated an increased risk of CVC-associated GN-BSIs related to self-IV infusion, bathing habits, and frequency of ND changes. The infection control practices associated with ND use may expose susceptible patients to increased risk of BSI. Based on our preliminary findings, general recommendations for preventing bacterial IV catheter-related infections associated with needleless IV access devices were included in the CDC's guidelines for preventing opportunistic infections in HCST recipients.²⁴ HCST recipients should cover and protect the catheter tip or end cap during bathing or showering to protect it from tap water contamination; change the device in accordance with manufacturers' recommendations, if available; and have a caregiver perform IV infusions whenever possible. Moreover, HSCT recipients and their caregivers should be educated on the proper care of IV NDs. Adherence to these recommendations regarding the use and maintenance of NDs to prevent BSIs in HSCT patients is essential to improve patient outcomes.

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