CLINICAL STUDY

Clinical Predictors of Port Infections in Adult Patients with Hematologic Malignancies

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ABSTRACT

Purpose: To identify clinical predictors of port infections in adult patients with hematologic malignancies.

Materials and Methods: A retrospective chart review identified 223 adult patients (age $\geq$ 18 y) with hematologic malignancies, including lymphoma (n = 163), leukemia (n = 49), and others (n = 11), who had a port placed from 2012 to 2015. Early (< 30 d after port placement) and overall port infections (bloodstream and site infections) were recorded. To elucidate clinical predictors for early and overall port infections, proportional subdistribution hazard regression (PSHREG) analyses were conducted with variables including patients' demographics, medications used, laboratory data, and port characteristics.

Results: Total duration of follow-up was 83,722 catheter-days (median per patient, 274 catheter-days). Early and overall port infections were identified in 8 (3.6%) and 26 (11.7%) patients, respectively. Early and overall infection rates were 1.2 and 0.3 infections/1,000 catheter-days, respectively. Backward stepwise multivariate PSHREG analyses identified hypoalbuminemia (< 3.5 mg/dL) at the time of port placement (hazard ratio = 5.03; 95% confidence interval, 1.14–22.16; $P = .03$) and steroid use (> 30 d cumulatively during follow-up period) (hazard ratio = 3.41; 95% confidence interval, 1.55–7.47; $P = .002$) as independent risk factors for early and overall port infections, respectively.

Conclusions: In adult patients with hematologic malignancies, hypoalbuminemia at the time of port placement was a clinical predictor for early port infections, whereas steroid use was a clinical predictor for overall port infections.

ABBREVIATIONS

ANC = absolute neutrophil count, BSI = bloodstream infection, CIF = cumulative incidence function, PSHREG = proportional subdistribution hazard regression

Hematologic malignancies are neoplastic diseases that begin in and affect the hematopoietic and lymphoid tissues. Clinical presentations of hematologic malignancies include various forms of leukemia, lymphoma, and myeloma (1). Although hematologic malignancies constitute a heterogeneous group of cancers with different morphologic, immunophenotypic, genetic, and clinical features, cytotoxic chemotherapy is generally the mainstay of treatment. Patients with hematologic malignancies often require totally implantable venous access systems (ports) as reliable venous access for administration of chemotherapy. Despite progress in antibiotic therapy and infection control procedures, infection remains one of the most common long-term complications associated with ports. It is also the most common cause of premature port removal in adult patients with cancer, followed by mechanical complications and thrombosis (2,3). There are 2 types of port infections—port-site infection and bloodstream infection (BSI). Together, they are reported to occur at a rate of 0.15–0.43 per 1,000 catheter-days (4–6).

Patients with hematologic malignancies have been reported to have a higher risk of port infection compared with patients with solid malignancies, presumably owing to their impaired immune systems secondary to the malignancies and the longer and more intense chemotherapeutic regimens (7,8). The impact of port infections on this immunocompromised patient population can be substantial. Port

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Table 1. Patient Demographics, Clinical History, and Relevant Medication Use

Characteristic	All Patients (n = 223)	Early Infection (n = 8)	Overall Infection (n = 26)
Age, y, median ± IQR	55 ± 17	63 ± 12	55 ± 17
Range	19–88	42–75	19–80
Sex			
Male	125 (56.1)	3 (37.5)	16 (61.5)
Female	98 (43.9)	5 (62.5)	10 (38.5)
BMI, mean ± SD	27.8 ± 9.05	32.7 ± 12.7	29.5 ± 14.6
Range	17–62	21–61	20–62
Diabetes mellitus	29 (13.0)	1 (12.5)	4 (15.4)
Prior port placement	10 (4.5)	2 (25.0)	2 (7.7)
Disease status			
Initial diagnosis	202 (90.6)	8 (100.0)	24 (92.3)
Recurrence	21 (9.4)	0 (0.0)	2 (7.7)
Malignancy class			
Lymphoma	163 (73.1)	6 (3.7)	16 (9.8)
Leukemia	49 (22.0)	2 (4.1)	9 (18.4)
Other	11 (4.9)	0 (0.0)	1 (9.1)
Diagnosis			
AML	16 (7.2)	2 (25.0)	4 (15.4)
ALL	18 (8.1)	0 (0.0)	4 (15.4)
CML	4 (1.8)	0 (0.0)	0 (0.0)
CLL	12 (5.4)	0 (0.0)	1 (8.3)
Non-Hodgkin lymphoma	125 (56.1)	3 (37.5)	12 (46.2)
Hodgkin lymphoma	38 (17.0)	3 (37.5)	4 (15.4)
Multiple myeloma	8 (3.6)	0 (0.0)	0 (0.0)
Other	2 (0.9)	1 (12.5)	1 (50.0)
Bone marrow transplantation	18 (8.1)	0 (0.0)	1 (3.8)
Medications			
Steroids	29 (13.0)	1 (12.5)	8 (30.7)
Anticoagulants	13 (5.8)	0 (0.0)	0 (0.0)
Antiplatelets	20 (9.0)	0 (0.0)	1 (3.8)

Note–Values are presented as number (column percent total) except where noted.
ALL = acute lymphocytic leukemia; AML = acute myelogenous leukemia; BMI = body mass index; CLL = chronic lymphocytic leukemia; CML = chronic myelogenous leukemia; IQR = interquartile range.

infections can lead to admission of the patients to the intensive care unit, longer hospital stays, higher medical expenses, and delays in treatment (9,10). To our knowledge, no standard guidelines for screening high-risk patients exist for port infections. The purpose of this study was to identify clinical predictors of port infections in adult patients with hematologic malignancies.

MATERIALS AND METHODS

Patients

This single-center retrospective study was in compliance with the Health Insurance Portability and Accountability Act and was approved by the institutional review board. Through a search of the picture archiving and communication system, 1,116 adult patients (age ≥ 18 y) with cancer who underwent port placement in the Division of Interventional Radiology between January 2012 and December 2015 were identified. During this period, 223 patients (20.0%) with hematologic malignancies underwent port placement and were included in this study. Electronic medical records and imaging studies of patients were reviewed to record baseline information, including patient demographics, clinical history, and relevant medications (Table 1) and port characteristics (Table 2). Relevant medications included for analysis were steroids (prednisone and dexamethasone), anticoagulants (warfarin and enoxaparin), and antiplatelet agents (aspirin and clopidogrel). Steroids were mostly used as part of chemotherapy regimens (prednisone 50–100 mg/d or dexamethasone 20–40 mg/d; n = 22) but were also used for chronic medical diseases, such as autoimmune disease (prednisone 5–35 mg/d; n = 7). Patients with steroid use were included when the duration of use was more than cumulative 30 days during the follow-up period. Patients with use of anticoagulants or antiplatelet agents were included when the duration of use was more than cumulative 6 months during the follow-up period. Relevant

Table 2. Port Characteristics

Characteristic	All Patients (n = 223)	Early Infection (n = 8)	Overall Infection (n = 26)
Port follow-up, d, median ± IQR	274 ± 391	14 ± 8	67 ± 230
Range	7–858	7–30	7–858
Outpatient/inpatient placement			
Outpatient	118 (52.9)	5 (62.5)	13 (50.0)
Inpatient	105 (47.1)	3 (37.5)	13 (50.0)
Port lumens			
Single lumen	85 (38.1)	2 (25.0)	6 (23.1)
Double lumen	138 (61.9)	6 (75.0)	20 (76.9)
Port laterality			
Left-sided port	21 (9.4)	1 (12.5)	3 (11.5)
Right-sided port	202 (90.6)	7 (87.5)	23 (89.5)

Note–Values are presented as number (column percent total) except where noted.
IQR = interquartile range.

Table 3. Laboratory Values at Time of Port Placement

Laboratory Test	All Patients (n = 223)	Early Infection (n = 8)
ANC, × 1,000 cells/μL, mean ± SD	4.60 ± 4.37	4.70 ± 4.35
Range	0.2–149.6	0.4–58.0
Neutropenia	23 (10.3)	1 (12.5)
WBC, × 1,000 cells/μL, mean ± SD	7.20 ± 6.10	6.15 ± 7.78
Range	0.7–206.0	0.7–62.5
Leukopenia	41 (18.4)	2 (25.0)
Platelets, × 1,000 cells/μL, mean ± SD	205 ± 162	173.0 ± 122.8
Range	16–827	16–437
Thrombocytopenia	68 (30.5)	3 (37.5)
Albumin, g/dL, mean ± SD	3.9 ± 0.9	3.85 ± 1.75
Range	1.1–5.2	1.9–5.0
Hypoalbuminemia	51 (23.8)*	5 (62.5)
INR, mean ± SD	1.0 ± 0.15	1.05 ± 0.21
Range	0.64–4.10	0.87–2.14
INR > 1.5	18 (8.4)*	2 (25.0)

Note–Values are presented as number (column percent total) except where noted.
ANC = absolute neutrophil count; INR = international normalized ratio; WBC = white blood cell count.
*For these laboratory values, only 214 data points (96%) were available, and percentages were calculated based on valid data points.

laboratory values at the time of port placement were also recorded (Table 3).

Mean age at time of port insertion was 55 years (range, 19–88 y), and there was a slight male predominance (56.1%). Non-Hodgkin lymphoma was the most frequent diagnosis (56.1%) followed by Hodgkin lymphoma (17.0%) and acute lymphocytic leukemia (8.1%). Nearly half (47.1%) of the ports were placed in an inpatient setting. At the time of port placement, the mean white blood cell count was 7,200 cells/μL (range, 700–206,000 cells/μL), and mean absolute neutrophil count (ANC) was 4,600 cells/μL (range, 200–14,960 cells/μL). Nine patients (4.0%) had ANC < 500 cells/μL. The mean platelet count was 205,000 cells/μL (range, 16,000–827,000 cells/μL). The mean albumin level was 3.9 g/dL (range, 1.1–5.2 g/dL), and mean international normalized ratio was 1.0 (range, 0.64–4.1).

Port Placement

Patients' coagulation parameters were evaluated before port placement, and coagulopathies (international normalized ratio > 1.5 or platelet count < 50,000 cells/μL) were corrected as needed. Port placement was generally avoided in patients with severe neutropenia (ANC < 500 cells/μL) because of the reported risk of port infection (11,12). All patients were given a prophylactic intravenous antibiotic, either 1 g cefazolin or 600 mg clindamycin for patients with penicillin allergy, before port placement. Either a single-lumen port (Dignity CT Ports; Medcomp, Harleysville, Pennsylvania) or double-lumen port (Deltec PORT-A-CATH; Smiths Medical, Minneapolis, Minnesota) was placed in standard fashion (13). The choice of port type was at the discretion of the referring oncologist. All procedures were performed in interventional radiology suites using a strict aseptic technique. The right internal jugular vein was generally accessed under ultrasound guidance; however, the left internal jugular vein was used when the right internal jugular vein was thrombosed or when the right upper chest was previously irradiated. The port pocket was closed with 2 or 3 interrupted subcutaneous 2-0 Vicryl sutures (Ethicon Inc, Somerville, New Jersey) and uninterrupted 4-0 Vicryl sutures using a running subcuticular technique. Dermabond (Ethicon Inc) and Steri-Strips (3M, St. Paul, Minnesota) were attached to the incision. The venous access and port pocket incision sites were covered with adhesive wound dressings (Covaderm; DeRoyal, Powel, Tennessee).

Definitions

The definitions of 2 types of port infection recorded in this study are described in US Centers for Disease Control guidelines (14). Port-site infections were defined as superficial erythema of the skin overlying the port or along the subcutaneous tract with or without positive culture or dehiscence of the wound with purulent discharge. BSI requires at least 1 of the following: (*i*) patient has a recognized pathogen cultured from ≥ 1 blood cultures, and organism cultured from blood is not related to an infection at another site; (*ii*) patient has at least 1 of the following signs or symptoms—fever (> 38°C), chills, or hypotension—and signs and symptoms and positive laboratory results are not related to an infection at another site, and common

commensal is cultured from ≥ 2 blood cultures drawn on separate occasions. Early port infection was defined as port infections that occurred within the first 30 days of placement according to the Society of Interventional Radiology (SIR) reporting guidelines (15). The abnormal laboratory value categories were defined as follows: leukopenia as white blood cell count < 4,000 cells/μL, neutropenia as ANC < 1,500 cells/μL, thrombocytopenia as platelet count < 150,000 cells/μL, hypoalbuminemia as serum albumin level < 3.5 mg/dL, and coagulopathy as international normalized ratio > 1.5. The duration of port follow-up was defined as time from the date of port placement to the date of port removal, the date of the patient's death while the port was in situ, or the date of the most recent follow-up visit to the oncology clinic while the port was in situ. This was recorded as catheter-days.

Follow-up and Statistical Analysis

All ports were followed by the referring oncology service. The date and type of port infections and blood culture results were recorded through chart review. The rates of early and overall infections (infections per 1,000 catheter-days) were calculated. Predictors for early and overall port infections were identified with proportional subdistribution hazard regression (PSHREG) analysis. Patients were censored for death not related to port infection, lost to follow-up, or ports still in use at the time of last follow-up. Competing events were any events not related to infection resulting in port removal. Laboratory values at the time of port placement were included in analysis for early port infections; however, they were not included in analysis for overall port infections. Variables with $P < .1$ in univariate PSHREG analysis were then included in backward stepwise multivariate PSHREG analysis. On each variable, the estimated hazard ratios with 95% confidence intervals were reported. To compare time to port infection according to the significant variables on multivariate analysis, the estimated cumulative incidence function (CIF) of port infection was calculated and compared with a Gray test of equality. SAS Studios Version 3.6 (SAS Institute Inc, Cary, North Carolina) was used for statistical analyses. For PSHREG analyses and estimated CIF calculations, SAS Studio software macros %PSHREG (16) and %CIF (17) were used, respectively. A P value of < .05 was considered statistically significant.

RESULTS

Total duration of follow-up was 83,722 catheter-days (median per patient, 274 catheter-days).

Early Port Infections

Eight patients (3.6%) were found to have port infections within the first 30 days. The 30-day port infection rate was 1.2 infections per 1,000 catheter-days. Five (62.5%) of these patients had port infection within the first 15 days. The median time to early port infection was 14 days (range, 7–30 d). Details of early port infections are summarized in Table 4. Seven of 8 patients with early port infections had BSIs, including 3 with both BSIs and port-site infections. The ports were removed in all patients at the time of early port infections. Demographics, port characteristics, and laboratory values at the time of port placement of patients with early port infections are shown in Tables 1, 2, and 3. No patients with early port infections were taking any relevant medication except for 1 patient taking steroids. Therefore, relevant medications were excluded from univariate PSHREG analysis for early port infections. In univariate PSHREG analyses, hypoalbuminemia at the time of port placement ($P = .02$) reached statistical significance and was included in multivariate analysis, along with diagnosis of acute myelogenous leukemia ($P = .06$) and coagulopathy at the time of port placement ($P = .09$) (Table 5). No neutropenia, leukopenia, thrombocytopenia, or coagulopathy at the time of port placement was a statistically significant variable for early port infections. In multivariate analysis, hypoalbuminemia and coagulopathy remained in the final regression model; however, hypoalbuminemia was the only variable that remained statistically significant for early port infections (hazard ratio = 5.03; 95% confidence interval, 1.14–22.16; $P = .03$) (Table 5). Statistically significantly higher estimated CIF was observed in patients with hypoalbuminemia at the time of port placement compared with their counterparts ($P = .02$) (Fig 1).

Table 4. Summary of Port Infections

	Early Infection	Overall Infection
Total	8	26
Bloodstream infection	4 (50.0%)	17 (65.4%)
Port-site infection	1 (12.5%)	4 (15.4%)
Both	3 (37.5%)	5 (19.2%)
Median time to infection, d	14	67
Infection rate per 1,000 catheter-days	1.2	0.3

Overall Port Infections

During the follow-up period, 26 patients (11.7%) were found to have port infections. The overall port infection rate was 0.3 infections per 1,000 catheter-days. The median time to overall port infection was 67 days (range, 7–858 d). Details of overall port infections are summarized in Table 4. Of 26 patients, 22 (84.6%) had BSIs, including 5 patients with both BSIs and port-site infections. The ports were removed in 24 patients at the time of port infection. The other 2 patients with port infections (both with port-site infections) were treated with oral antibiotics, and the ports were eventually removed after completion of chemotherapy. The demographics and port characteristics of these patients are shown in Tables 1 and 2. In univariate PSHREG

Table 5. PSHREG Analysis of Possible Risk Factors for Early Port Infections

Risk Factors	HR (95% CI)	*P* Value
Univariate		
Age < 60 y	0.69 (0.17–2.73)	.59
BMI > 30	0.6 (0.12–2.94)	.53
Sex	0.62 (0.42–1.43)	.19
Diabetes mellitus	0.98 (0.12–7.07)	.98
Prior port placement	NA	NA
Cancer recurrence	1.21 (0.56–3.12)	.98
Double lumen	1.88 (0.72–3.19)	.44
Lymphoma	1.12 (0.25–5.96)	.88
Leukemia	1.17 (0.24–5.70)	.85
Bone marrow transplantation	NA	NA
AML	4.37 (0.91–20.51)	.06*
ALL	NA	NA
CLL	NA	NA
Non-Hodgkin lymphoma	0.46 (0.11–1.92)	.29
Hodgkin lymphoma	3.01 (0.74–12.38)	.12
Outpatient/inpatient	0.69 (0.16–2.88)	.62
Leukopenia	0.54 (0.17–1.44)	.14
Thrombocytopenia	1.38 (0.32–5.68)	.66
Hypoalbuminemia	5.69 (1.29–23.33)	.02†
Coagulopathy	3.92 (0.81–19.04)	.09*
Neutropenia	2.55 (0.52–12.47)	.25
Multivariate		
Hypoalbuminemia	5.03 (1.14–22.16)	.03†
Coagulopathy	4.49 (0.79–25.43)	.09

ALL = acute lymphocytic leukemia; AML = acute myelogenous leukemia; BMI = body mass index; CI = confidence interval; CLL = chronic lymphocytic leukemia; HR = hazard ratio; NA = nonapplicable owing to small number of patients within the subgroup; PSHREG = proportional subdistribution hazard regression.
*Incorporated in multivariate logistic regression.
†Significance at .05 level.

analyses, steroid use ($P = .03$) reached statistical significance and was included in the multivariate analysis, along with broad diagnosis of lymphoma ($P = .09$), broad diagnosis of leukemia ($P = .07$), diagnosis of acute myelogenous leukemia ($P = .05$), and double-lumen port ($P = .08$) (Table 6). In multivariate analysis, steroid use and use of a double-lumen port remained in the final regression model; however, steroid use was the only variable that remained statistically significant for overall port infections (hazard ratio = 3.41; 95% confidence interval, 1.55–7.47; $P = .002$) (Table 6). Statistically significantly higher estimated CIF was observed in patients with steroid use compared with their counterparts ($P = .01$) (Fig 2).

Blood Culture Results

Blood culture results from 22 patients with BSIs are shown in Table 7. There were 25 bacterial strains isolated. Gram-positive bacteria were dominant in both early (71.4%) and overall (72.0%) port infections; however, gram-negative bacteria were also seen in 2 patients (28.6%) with early port infections and 7 patients with overall port infections (28.0%). Two pathogens (methicillin-resistant *Staphylococcus aureus* and *Klebsiella pneumoniae*) were isolated in

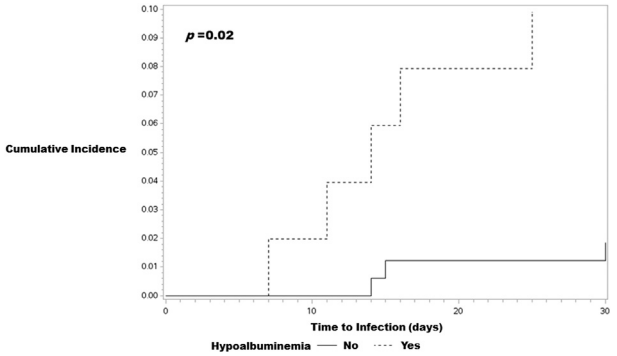

Figure 1. Estimated cumulative incidence of early port infection in patients with hypoalbuminemia (< 3.5 mg/dL) at the time of port placement.

Table 6. PSHREG Analysis of Possible Risk Factors for Overall Port Infections

Risk Factors	HR (95% CI)	*P* Value
Univariate analysis		
Age < 60 y	0.52 (0.23–1.17)	.21
BMI > 30	1.04 (0.78–1.13)	.29
Sex	0.77 (0.35–1.70)	.53
Diabetes mellitus	1.34 (0.48–3.78)	.31
Prior port placement	1.91 (0.47–7.71)	.82
Cancer recurrence	1.64 (0.89–1.99)	1.32
Double lumen	2.21 (0.97–2.69)	.08*
Lymphoma	0.51 (0.23–1.12)	.09*
Leukemia	2.13 (0.95–4.75)	.07*
Bone marrow transplantation	0.61 (0.17–2.24)	.55
AML	2.95 (0.99–4.02)	.050*
ALL	2.05 (0.30–14.1)	.23
CLL	0.79 (0.12–5.14)	.81
Non-Hodgkin lymphoma	0.58 (0.27–1.24)	.16
Hodgkin lymphoma	1 (0.14–7.38)	1
Outpatient/inpatient	1.18 (0.54–2.56)	.69
Anticoagulant use	NA	NA
Steroid use	3.35 (1.51–7.45)	.03†
Antiplatelet use	0.67 (0.13–7.38)	.51
Multivariate analysis		
Steroid use	3.41 (1.55–7.47)	.002†
Double lumen	2.26 (0.93–5.46)	.07

ALL = acute lymphocytic leukemia; AML = acute myelogenous leukemia; BMI = body mass index; CI = confidence interval; CLL = chronic lymphocytic leukemia; HR = hazard ratio; NA = nonapplicable owing to small number of patients within subgroup making the analysis invalid; PSHREG = proportional subdistribution hazard regression.
*Incorporated in multivariate logistic regression.
†Significance at .05 level.

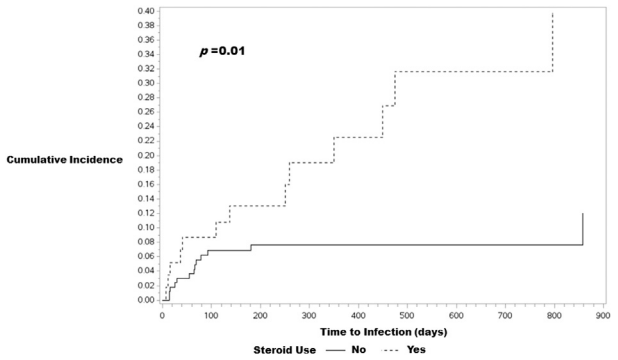

Figure 2. Estimated cumulative incidence of overall port infection in patients on steroids (> 30 d cumulatively during the study period).

1 patient, and 3 pathogens (*Enterococcus faecalis*, *Escherichia coli*, and *Proteus mirabilis*) were isolated in another patient.

DISCUSSION

Although extensively investigated, no universally accepted clinical predictors or risk factors of port infections have been identified to date. Researchers have reported various risk factors of infectious complications related to long-term central venous catheters, including ports, such as neutropenia (11,12), double-lumen catheter (18,19), outpatient placement (20), total parenteral nutrition (12,21), and hematologic malignancies (7,8). This array of risk factors is likely due to the diverse clinical backgrounds of patients included in these studies and differences in variables investigated. With this in mind, only adult patients with hematologic malignancies were included in the present study, and > 20 variables related to patient demographics, clinical history, medications used, and laboratory values at the time of port placement and port characteristics were investigated. Multivariate analysis showed that hypoalbuminemia (< 3.5 g/dL) was an independent risk factor for early port infections, and steroid use as part of chemotherapy regimens or for chronic medical disease was an independent risk factor for overall port infections.

Hypoalbuminemia is an indicator of protein-energy malnutrition and is well known to negatively impact the immune system and wound healing (22). The cutoff value of < 3.5 g/dL was previously demonstrated to be associated with poor clinical outcomes in a variety of acute conditions in surgical and nonsurgical settings (23). Although previous surgical work found that perioperative hypoalbuminemia is a significant risk factor for postoperative complications, including infectious complications (24,25), hypoalbuminemia is not known to be associated with port infection to our knowledge. In contrast to the present results, hypoalbuminemia was not a risk factor for early port infections in a case-control study by Bamba et al (26), which included 33 patients with early port infections and 66 control patients without early port infections. Direct comparison of the present results with the observation of Bamba et al (26) is probably of no clinical value, as the patient backgrounds are different. Their study included a general cancer population with hematologic malignancies constituting only 15% of the cohort. Hypoalbuminemia was prevalent in 23% (51/223) of the patient population in the present study, and 10% (5/51) of patients with hypoalbuminemia developed early port infections. Given the high incidence of early port infections among patients with hypoalbuminemia, studies with larger cohorts comprising this population are warranted to further investigate and validate the impact of hypoalbuminemia on early port infections.

Table 7. Culture Results of Bloodstream Infection in 22 Patients

Bacterial Strains	Early Infection	Overall Infection
Total	7	25
Gram-positive bacteria	5 (71.4%)	18 (72.0%)
Staphylococcus spp.		
Coagulase-positive (MRSA)	2 (0)	10 (4)*
Coagulase-negative (*S. epidermidis*)	2 (1)	4 (3)
Streptococcus spp.	1	2
Listeria monocytogenes		1
Enterococcus faecalis		1†
Gram-negative bacteria	2 (28.6)	7 (28.0)
Escherichia coli	1	3†
Klebsiella pneumoniae	1	2*
Proteus mirabilis		1†
Serratia marcescens		1

MRSA = methicillin-resistant staphylococcus aureus.
*One patient had 2 pathogens isolated from the blood cultures.
†One patient had 3 pathogens isolated from the blood cultures.

Routine use of prophylactic antibiotics before port placement remains controversial. In the present study, the impact of routine administration of prophylactic intravenous antibiotics on early port infections is uncertain given the lack of a control group. A meta-analysis including 2,154 patients found no significant difference in port infection rates between groups with and without prophylactic antibiotics (27). Periprocedural prophylactic antibiotics for port placement are not advised in the most recent SIR clinical guidelines (28) and Centers for Disease Control and Prevention recommendations (29). SIR guidelines do recommend a case-by-case approach for use of prophylaxis in immunocompromised patients. Based on observations in the present study, prophylactic antibiotics may be of clinical value in patients with hypoalbuminemia; however, further investigation is necessary to validate such an approach in this population.

Steroid use as part of chemotherapy regimens or for chronic medical disease was an independent risk factor for

overall port infections in this study. Steroids are commonly used in patients with hematologic malignancies because of their antineoplastic effect (30,31) and efficacy against excessive bone resorption and paraneoplastic syndromes, which are often seen in patients with multiple myeloma and lymphoma (32). Consistent with the present results, several researchers have reported long-term steroid use to be a risk factor of port infections in the general cancer population (12,21). Steroids exert a broad range of inhibitory effects on immune responses (33). Therefore, long-term steroid use could predispose patients with hematologic malignancies, whose immune systems are likely impaired, to port infections. As most long-term steroid use (75.9%, 22/29) occurred as part of chemotherapy regimens in this study, this risk factor is unlikely to be modified owing to the necessity of cancer treatment.

Previous reports have identified severe neutropenia (< 500 cells/μL) to be a significant risk factor of port infections in general cancer populations (11,12). Based on these observations, port placements in patients with severe neutropenia were generally avoided in our institution. In the present study, only 1 early port infection was observed among patients with neutropenia (< 1,500 cells/μL) (4.3%, 1/23), and the patient was severely neutropenic (410 cells/μL) at the time of port placement. Segel and Halterman (34) noted that patients with severe neutropenia (< 500/μL) are most susceptible to bacterial infection; however, patients with moderate neutropenia (ANC 500–1,000/μL) are much less frequently or severely affected, whereas patients with mild neutropenia (ANC 1,000–1,500/μL) have little or no heightened risk for such infections. Our observation supports the remark made by Segel and Halterman (34).

The early port infection rate in this study of 1.2 infections per 1,000 catheter-days is within the range of rates previously reported in general cancer populations (0.7–1.34 infections/1,000 catheter-days) (26,35). Likewise, the overall port infection rate of 0.3 infections per 1,000 catheter-days is within the range of previously reported rates (0.15–0.43/1,000 catheter-days) in general cancer populations (4–6). Although the infection rates in this study did not suggest patients with hematologic malignancies are more prone to port infection than general cancer populations, the impact of port infections in patients with hematologic malignancy can be substantial. Further investigations to establish standard guidelines for screening high-risk patients for port infections are needed.

The present study has several limitations, mainly owing to its retrospective nature and relatively small sample size. First, although a heterogeneous group of hematologic malignancies was included, patients with non-Hodgkin lymphoma constituted 56.1% of the study population. In addition, only adult patients were included in this study. Therefore, the results may not be generalized to the general patient population with hematologic malignancies or pediatric patients. Second, as a large number of variables were included compared with the relatively small sample size, the numbers of patients in some variables might not be enough to yield statistical power. A multicenter study including a larger number of patients may mitigate this limitation and further elucidate subgroups at a higher risk of port infection; however, possible selection bias would remain.

In conclusion, this study identified that hypoalbuminemia (< 3.5 mg/dL) at the time of port placement is a clinical predictor of early port infections in adult patients with hematologic malignancies, whereas long-term steroid use as part of chemotherapy regimens or for chronic medical disease is a clinical predictor for overall port infections. Identifying clinical predictors of port infection serves as a starting point for prospective studies to establish guidelines for screening high-risk patients for port infections in this patient population.

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