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Concise Communication

Impact of number of lumens in central-venous catheters on central-line bloodstream infection (CLABSI) and venous thromboembolism (VTE) risk in patients with acute leukemia

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Abstract

This retrospective study was conducted to determine whether the number of peripherally inserted central-catheter lumens affected the rate of central-line associated bloodstream infections (CLABSIs) in adult patients with acute leukemia. The results show that CLABSI rates were not significantly different between patients with triple-lumen or double-lumen PICCs (22.1% vs 23.4%; $P = .827$).

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Patients with acute myeloid leukemia (AML) and acute lymphoblastic leukemia (ALL) often require placement of multiple-lumen peripherally inserted central catheters (PICCs), due to the high complexity of care.[1] However, studies have suggested that increasing the number of PICC lumens is associated with an increased risk of central-line–associated bloodstream infections (CLABSIs) and that triple-lumen PICCs are associated with the highest rates.[1–4] Additionally, long-term PICC use increases the risk for line-associated deep vein thrombosis (DVT), which may also be related to lumen number and size.[1,5]

Prior studies that have associated lumen number with risk of vascular-related complications have analyzed all hospitalized patients regardless of underlying diagnoses. Treatment with intensive chemotherapy and neutropenia are also associated with an increased risk for CLABSI independent of lumen number, a possible source of selection bias in these studies.[1–3,7] Here, we evaluated the impact of the number of PICC lumens on vascular complications in patients with acute leukemia.

Methods

Study design

We conducted a single-center, retrospective cohort study of adult AML and ALL patients admitted for therapy at the University of Michigan from 2016 to 2019. Patients were excluded if they had been admitted for <72 hours, if no PICC was placed during admission, or if they received nonintensive induction therapy. Patients were divided into 2 cohorts: those with double-lumen PICCs and those with triple-lumen PICCs. The choice of lumen number was made by the treating hematologist, based on anticipated complexity of care. The study was approved by our institutional review board.

The primary end point was the incidence of CLABSI, defined according to National Healthcare Safety Network (NHSN) at the Center of Disease Control criteria.[6] Secondary end points included the incidence of LCBI associated with mucosal barrier injury (MBI-LCBI), secondary BSI, line-associated DVT, and the proportion of patients who required additional peripheral intravenous (PIV) access. Patients were followed for clinical outcomes until PICC removal or discharge, whichever came first. Only the first PICC and the incidence per clinical outcome were considered per patient.

The χ^2 test or Fisher exact test was used for categorical variables, and the Student t test or Mann–Whitney U test was used for continuous variables. A multivariable analysis was performed to determine whether any variables, including lumen number, affected CLABSI incidence. Variables with a P value <.20 on univariable analysis were considered for inclusion in the multivariable model. $P < .05$ was considered statistically significant. IBM SPSS software (IBM, Armonk, NY) was used for statistical analyses.

Results

In total, 318 patients with a diagnosis of AML or ALL were assessed. Reasons for exclusion are detailed in Supplementary

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Table 1. Baseline Characteristics

Variable	Double-Lumen PICCs (n = 94), No. (%)[a]	Triple-Lumen PICCs (n = 113), No. (%)[b]	*P* Value
Age, median y (range)	61 (24–82)	57 (21–79)	.030*
Sex, Female	35 (37.2)	52 (46)	.202
BSA, mean (SD)	2.02 (±0.24)	2.02 (±0.28)	.890
Charlson comorbidity index, median (range)	4 (2–9)	4 (2–9)	.137
One chemotherapy induction only	76 (80.9)	99 (87.6)	.180
Duration of PICC use, median d (range)	20 (3–53)	20 (5–68)	.541
Length of stay, median d (range)	26 (9–68)	25 (15–97)	.241
Antibiotic use of ≥72 h	84 (89.4)	104 (92)	.507
Diagnosis			
Acute myeloid leukemia	23 (24.5)	34 (30.1)	.812
Acute lymphoblastic leukemia	71 (75.5)	79 (69.9)	
Vein type			
Basilic	64 (68.1)	89 (78.8)	.202
Brachial	21 (22.3)	18 (15.9)	
Other	9 (9.6)	6 (5.3)	
Chemotherapy[b]			
7+3	33 (35.1)	53 (46.9)	.086
FLAG	37 (39.4)	26 (23.0)	.011*
Larson protocol	11 (11.7)	17 (15.0)	0.484
HyperCVAD A	3 (3.2)	12 (10.6)	.040*
HyperCVAD (A and/or B)	4 (4.3)	13 (11.5)	.059
Others	14 (14.9)	10 (8.8)	.176

Note. BSA, body surface area; PICC, peripherally inserted central catheter; FLAG, fludarabine, cytarabine, and G-CSF chemotherapy; hyperCVAD, fractionated cyclophosphamide, vincristine, doxorubicin, and dexamethasone chemotherapy.
[a]Unless otherwise stated.
[b]Chemotherapy n is >207 due to multiple inductions in some patients.
*P value < .05.

Figure S1 (online). Ultimately, 207 patients were included in the final analysis (113 with triple-lumen PICCS and 94 with double-lumen PICCs). Baseline characteristics were relatively balanced between the double-lumen and triple-lumen groups (Table 1), with the exception of median age (61 years vs 57 years; $P = .03$), FLAG (fludarabine, cytarabine, and G-CSF) chemotherapy (39.4% and 23.0%; $P = .011$) and hyperCVAD A (fractionated cyclophosphamide, vincristine, doxorubicin, and dexamethasone) chemotherapy (3.2% vs 10.6%; $P = .04$).

The total incidence of CLABSI was not different between the 2 groups: 22 patients (23.4%) in the double-lumen group and 25 patients (22.1%) in the triple-lumen group ($P = .827$). Mucosal barrier injury laboratory-confirmed bloodstream infection (MBI-LCBIs) were identified in 13 patients (13.8%) in the double-lumen group and in 15 patients (13.3%) in the triple-lumen group ($P = .907$) (Table 2). Line-associated DVT occurred in 3 patients (3.2%) in the double-lumen group and in 5 patients (4.4%) in the triple-lumen group ($P = .731$). Additional PIV access was required significantly more frequently in patients with double-lumen PICCs (34% vs 14.2%; $P = .001$).

No baseline characteristics or disease-specific variables were statistically significant predictors of CLABSI according to univariable or multivariable logistic regression analyses (Supplementary Table S1 online). Overall, 63% of organisms isolated were gram-negative organisms. The most commonly isolated organism was *Escherichia coli* (28% of positive blood cultures) (Supplementary Table S2 online).

Discussion

We detected no statistically significant difference in the rate of CLABSI based on lumen number in patients with acute leukemia. The combination of a prolonged duration of neutropenia, mucositis, and barrier disruption due to lines and invasive procedures puts this population at the highest risk among cancer patients for bacteremia.[7] Accordingly, our analysis demonstrated a 22.7% rate of CLABSI overall, similar to prior studies in leukemia patients, and significantly higher than the rates in general hospitalized patients (~6%).[3,4,7]

Although patients were statistically older in the double-lumen group, the absolute difference was small (61 vs 57 years) and was not likely to have affected the rate of CLABSI. Notably, significantly more patients received FLAG chemotherapy in the double-lumen group, a non–anthracycline-containing AML regimen with a shorter duration of neutropenia and less toxicity compared to standard AML induction chemotherapy regimens (eg, 3+7).[8]

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Table 2. Primary and Secondary Outcome Comparison[a]

Variable	Patients With Double-Lumen PICCs (n = 94), No. (%)	Patients With Triple-Lumen PICCs (n = 113), No. (%)	*P* Value
Primary outcomes			
CLABSI	22 (23.4)	25 (22.1)	.827
CLABSI – MBI-LCBI	13 (13.8)	15 (13.3)	.907
CLABSI – non-MBI-LCBI	9 (9.6)	10 (8.8)	.857
Secondary outcomes			
DVT	3 (3.2)	5 (4.4)	.731
PIV use (additional IV access)	32 (34)	16 (14.2)	.001**

Note. PICC, peripherally inserted central-venous catheter; CLABSI, central-line–associated bloodstream infection; MBI, mucosal barrier injury; LCBI, laboratory-confirmed bloodstream infection; DVT, deep vein thrombosis; PIV, peripheral intravenous; IV, intravenous.
[a]Incidence of CLABSI, DVT and PIV use, and CLABSI-MBI in patients with triple-lumen or double-lumen PICCs.
**Statistically significant.

Despite these differences in baseline characteristics, according to multivariable logistic regression, there was no association between CLABSI incidence and number of PICC lumens.

Importantly, more than half of all CLABSI events were MBI-LCBIs. This finding suggests that a significant proportion of bacteremias in this population may be a function of mucosal barrier injury due to mucositis-inducing chemotherapy, rather than related to the presence of a PICC. The microbiologic data are concordant with this premise: most of the organisms isolated were of enteric origin, consistent with prior studies of hematology patients.[7]

Notably, the incidence of PICC-associated DVT was low and did not differ between groups (3.2% vs 4.4%). Given the low incidence, we were not powered to detect any possible difference in the rate of DVT; however, this may be significantly affected by differences in the thrombotic potential of leukemia subtypes (eg, APL), as well as therapies that significantly increase the risk of thrombosis in this population (eg, asparaginase).[9]

Although rates of CLABSI and DVT did not differ, the need for additional PIVs was more than twice as high in patients with double-lumen PICCs and occurred in 34% of patients. This finding may represent a significant quality of life (QOL) burden in acute leukemia patients already at high risk for bleeding complications because PIVs are typically replaced every 72–96 hours.[10] The impact the requirement for additional PIV placement has on delays in medication administration and other care remains unknown.

This study had several limitations. First, it was a single-center study of hospitalized patients with acute leukemia. These results should not be extrapolated to outpatient hematology and oncology patients, including those with a lower rate of bacteremia and other complications. Such patients may not require central venous access nor multiple-lumen PICCs. As such, when choosing a PICC, a risk-guided approach should be considered, weighing the complexity of care with the aim to avoid central venous access when not necessary (Supplementary Fig. S2 online). Such an approach created by our center in response to these results is shown in Supplementary Figure S3 (online). Second, despite our multivariable analysis, we cannot exclude selection bias in the choice of lumen number. However, we would expect higher-risk patients to have more lumens placed in anticipation of a higher complexity of care; thus, a similar CLABSI rate in the triple-lumen group is reassuring. Finally, without prospective data, we cannot confirm any possible adverse impact of more frequent PIV access on patient satisfaction and broader QOL outcomes.

In conclusion, we detected no relationship between the number of PICC lumens and the incidence of CLABSI or DVT in patients with acute leukemia undergoing intensive chemotherapy. The use of a double-lumen PICC was associated with a >2-fold increase in the rate of requiring additional venous access, which may affect QOL.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/ice.2021.423

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