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Risk factors for Central Line-associated Bloodstream Infections: A Focus on Comorbid Conditions

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Narrative abstract

CDC risk adjustment methods for CLABSI only adjust for ICU type. This cohort study explored risk factors for CLABSI using two comorbidity classification schemes, the Charlson Comorbidity Index and the Chronic Disease Score. Our study supports the need for additional research into risk factors for CLABSI, including electronically-available comorbid conditions.

Current methods used by the National Healthcare Surveillance Network (NHSN) and CDC for Central line-associated bloodstream infection (CLABSI) risk adjustment consist solely of adjustment by the type of intensive care unit.¹ There are numerous criticisms of this risk adjustment methodology for CLABSI and for other healthcare-associated infections (HAIs).^{2,3}

Comorbid conditions have been shown to increase risk for surgical site infections^{4,5} and the acquisition of antibiotic-resistant bacteria.⁶ This led us to postulate that patients with certain comorbid conditions may be at greater risk for CLABSI than other patients.

Methods

We performed a retrospective longitudinal study of intensive care unit (ICU) patients, age 18 years and older, who had central venous catheters. Patients were treated between July 1, 2010 and December 31, 2012 at one of six intensive care units (ICUs): surgical (SICU), medical (MICU), cardiac care (CCU), and three trauma (TICU) at the University of Maryland Medical Center (UMMC).

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The outcome, CLABSI, was defined according to guidelines set by the National Healthcare Safety Network (NHSN)/CDC. The diagnosis of CLABSI was made by infection preventionists as part of routine infection prevention practice at UMMC.⁷ The validation of the infection preventionists' classification is done by a senior infection preventionist and then reviewed by a physician-hospital epidemiologist.

Eligible patients had to have had a central line for at least 48 hours and no prior CLABSI. The daily presence or absence of a central line was obtained from daily nursing records. Data was not available to determine whether patients had multiple simultaneous central venous catheters.

The two different composite comorbidity scores and their individual components were evaluated; these scores were the Chronic Disease Score (CDS) and the Charlson Comorbidity Index (CCI).^{8,9} A major benefit of these scores is that they are available through common hospital electronic medical and billing records.

The CDS uses pharmacy records of patient medications ordered during the first 24 hours of a hospital admission as indicators for comorbid conditions. We used components of the CDS that has a range of 0–35. The CCI is calculated using ICD-9-CM discharge codes (International Classification of Diseases, 9th Revision, Clinical Modification) and has a range of 0–37.¹⁰ Because both scores measure comorbidity, separate analyses were performed for each composite comorbidity score as well as for the individual components of each of these measures. Other risk factors analyzed included age, sex, hospital and ICU length of stay prior to the outcome, and ICU unit type. Bivariate and multivariable analyses were performed.

Multivariable logistic regression, specifically generalized estimating equations (GEEs), was used to account for when patients contributed multiple visits to the analysis to account for correlation.

Results

4,011 subjects with a total of 32,577 central line days were included in this study. Among the 4011 subjects, 76 CLABSIs were identified, yielding a CLABSI rate of 2.33 per 1000 central line days. The mean age of the patients in the cohort was 57.3±16.4 years (mean ±SD); 59% (n=2846) were Caucasian, 35% (n=1686) were African American; and 41% (n=2052) were female (Table 1).

Patients with a CLABSI had more central line days than those without a CLABSI ($p<0.0001$); patients with a CLABSI had a median of 5.5 central line days (IQR: 4.0 to 12), while those with no CLABSI had a median of 4 line days (IQR: 2.0 to 7.0). The median ICU length of stay for those with a CLABSI was 25.3 days (IQR: 11.6 to 36.7) compared to 8.8 days (IQR: 4.8 to 18.6) for those with no CLABSI ($p<0.0001$). Length of stay refers to the number of ICU days from admission to positive culture date for those with a CLABSI and number of ICU days from admission to ICU discharge for those with no CLABSI.

The composite CCI had a median score of 2.0 (IQR: 1.0 to 4.0). Patients with a CLABSI had a median CCI of 3.0 (IQR: 1.0 to 4.5), while those with no CLABSI had a median of 2.0 (IQR: 1.0 to 4.0), ($p=0.26$). The mean composite CDS for those with a CLABSI was 9.0 ± 4.0 , and for those without the outcome it was 9.1 ± 3.9 ($p=0.83$) (Table 1).

The bivariate analysis for the individual components of the CCI and CDS were performed. For the CDS components, patients who had a CLABSI were more likely to use beta-blockers and diuretics, and beta-adrenergic agonists; and less likely to be on cholesterol lowering agents and anti-hypertensives (including calcium channel blockers).

Two components of the CCI, myocardial infarction and peripheral vascular disease, occurred less frequently in those who developed a CLABSI compared to those without. Patients who developed a CLABSI were more likely to have renal disease, liver disease, and cerebrovascular disease.

The multivariable CDS individual components model controlling for age and sex (Table 2) showed medication use including cholesterol lowering agents (OR=0.39; 95% CI: 0.17, 0.89) and antihypertensives including calcium channel blockers (OR=0.60; 95% CI: 0.36, 1.0) lowered risk for CLABSI, while receipt of beta blockers (OR=1.85; 95% CI: 1.04, 3.29), and the number of central line days (OR=1.04; 95% CI: 1.03, 1.06) were associated with increased risk for CLABSI.

The multivariable CCI individual components model controlling for age, and sex (Table 2) showed myocardial infarction lowered risk for CLABSI (OR=0.28; 95% CI: 0.10, 0.76), while kidney disease (OR=1.88; 95% CI: 1.16, 3.05), and number of central line days (OR=1.04; 95% CI: 1.03, 1.06) were associated with increased risk for CLABSI.

Discussion

We found that individual comorbid conditions obtained electronically by ICD-9 codes and admission medications can be used to identify risk factors for increased or decreased CLABSI events. The composite CDS and CCI scores were not risk factors. Additionally, we found that the number of central line days was a predictor of CLABSI, consistent with other studies. It is important to remember that the study revealed statistical associations that may not imply causality. Risk factors identified should always be supported by biological plausibility of the risk factors or future research that confirms the results.

This study has several limitations. First, it was performed at a single site, and had a small number of CLABSI events (76), this limits the number of important comorbid conditions that can be identified and affects the generalizability of the results. Certain patient level factors, such as line placement location, and line care were not available and have been associated with CLABSI in the literature. Additionally, the impact of patient's who have multiple central venous catheters in place simultaneously was not accounted for.

Hospital electronic record capabilities are expanding and allowing healthcare workers to document the presence and or absence of central venous catheters on a daily basis. Hospital databases are becoming more readily accessible to hospital epidemiologists and infection

preventionists. These hospital databases readily contain ICD-9 and ICD-10 codes and admission medications, which facilitates computation of the Charlson Comorbidity Index, the Chronic Disease Score and their components. Larger studies involving multiple U.S. hospitals could further our knowledge about risk factors for CLABSI and ultimately lead to improvement in the current CDC NHSN risk adjustment methodology. The identification of risk factors for CLABSI can also lead to hospital epidemiology interventions aimed at preventing these CLABSI among high-risk patients.

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Table 1

Baseline characteristics for all study subjects

Variables	Total (n=4950)	CLABSI (n=76)	Others (n=4874)	P
Chronic Disease Score (mean, std)	9.1(3.9)	9.0(4.0)	9.1(3.9)	0.83
Charlson total (median, IQR)	2.0(1.0–4.0)	3.0(1.0–4.5)	2.0(1.0–4.0)	0.26 ^a
Central line days (median, IQR)	4.0(2.0–7.0)	5.5(4.0–12)	4.0(2.0–7.0)	<0.0001 ^a
Age (yrs. mean, std)	57.3(16.4)	55.7(16.4)	57.3(16.4)	0.39
Male sex (count, %)	2898(59)	45(59)	2853(59)	0.9 ^b

Tests are Student's t-tests except ^a Wilcoxon rank sum and ^b Chisq tests. IQR: interquartile range. Std: standard deviation.

Table 2

Multivariable Logistic Regression model Predicting Central Line Associated Blood Stream Infections (CLABSI) Predicted by (1) Chronic Disease Score (CDS) components, adjusted for age, sex, and central line days or (2) Predicted by Charlson Comorbidity Index components, adjusted for age, sex, and central line days.

Variable	Outcome = CLABSI	
	Odds Ratio (95% CI)	P
Model1: CDS components model		
Cholesterol lowering agents (Yes vs. No)	0.39 (0.17 to 0.89)	0.026
Anti-hypertensives and calcium channel blockers (Yes vs. No)	0.60 (0.36 to 1.00)	0.050
Beta blockers and diuretics (Yes vs. No)	1.85 (1.04 to 3.29)	0.036
Central Line Days	1.04 (1.03 to 1.06)	<0.0001
Age (yrs)	1.00 (0.98 to 1.01)	0.85
Sex (Female vs. Male)	0.94 (0.59 to 1.50)	0.80
Model 2: Charlson components model		
Myocardial Infarction (Yes vs. No)	0.28 (0.10 to 0.76)	0.013
Renal Disease (Yes vs. No)	1.88 (1.16 to 3.05)	0.010
Central Line Days	1.04 (1.03 to 1.06)	<0.0001
Age (yrs)	0.99 (0.98 to 1.01)	0.43
Sex (Female vs. Male)	0.91 (0.57 to 1.46)	0.76

Note: MODEL 1: CLABSI= Anti-lipid medications + Antihypertensive + Beta blockers + Line days + age in years + sex. GEE was used to account for the non-independence of multiple data points coming from a given individual. MODEL 2: CLABSI= Myocardial infarction + Renal disease + Line days + age in years + sex. GEE was used to account for the non-independence of multiple data points coming from a given individual.