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A retrospective study of surgery and central line-associated bloodstream infections

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Southwestern Oklahoma State University

2011

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An abstract of

A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University

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Abstract

A retrospective study of surgery and central line-associated bloodstream infections

By Ashley Tippett, MLS(ASCP)^{CM}

Central line-associated blood stream infections (CLABSI) are one of the most common, preventable and costly healthcare associated infections and are thus a major concern to hospitals, providers, and patients. Although number of risk factors for the development of CLABSIs have been identified, little to no data on surgery as a risk factor have been published. Based on data from a previous study on CLABSI risk factors, surgery information was analyzed to determine if going to the operating room is associated with an increased risk of developing a CLABSI. Using multivariate analysis, any surgery was significantly associated with CLABSI (OR=2.85; 95% CI 1.57 – 5.17). The risk of CLABSI increased as the index score increased in those that had had surgery. These results lend insight into the relationship between surgery and CLABSIs, however further research is need in order to clarify and expand on the relationship.

A retrospective study of surgery and central line-associated bloodstream infections

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Contents

Background

Healthcare associated infections (HAIs) affect around 5% of those hospitalized in the United States annually and are among the top ten causes of death in the country (1-3). Central line-associated bloodstream infections (CLABSI) are one of the most common, preventable, costly, and well-tracked HAIs (4). They account for 14% of all HAIs per year and have a reported mortality rate of 12%-25% (1, 5). Efforts from state and federal agencies, professional societies, and healthcare personnel have worked to decrease the incidence of CLABSI, especially in intensive care units (ICUs) (1). However, while a decline in CLABSI cases can be seen in ICUs, a majority of CLABSIs are now occurring in inpatient wards and outpatient hemodialysis clinics. A majority of the improvement efforts for CLABSI reduction have focused on line insertion practices in the ICU. With the relative increase of CLABSIs occurring outside of the ICU, there is a need for a better understanding of and an expansion of prevention practices outside of the ICU.

The Centers for Disease Control and Prevention, using the National Healthcare Safety Network (NHSN) as a surveillance system, has standardized a definition for CLABSI in order to promote more accurate surveillance and reporting. A CLABSI is defined as a laboratory confirmed bloodstream infection, not secondary to an infection at another site in the body, after the central line is in place greater than 48 hours (1, 6). Difficulty differentiating between primary and secondary bloodstream infections is a limitation of the NHSN CLABSI definition.

The two most common pathways by which microorganisms gain access to the bloodstream and cause CLABSI are extraluminal and intraluminal. Extraluminal infection occurs when organisms on the patient's skin surface at the site of the catheter insertion contaminate the catheter and travel along the external catheter surface, eventually entering the bloodstream (6). Infections caused by skin organisms can be reduced by proper adherence to central line insertion practices. Intraluminal contamination is caused by the introduction of organisms during the manipulation of the catheter connector or hub (6). This contamination is most likely attributable

to failure to properly carry out hand hygiene protocols and failure to adequately clean the catheter hub (3). Non-tunneled central lines tend to be in place for a shorter duration and thus infections are generally attributed to extraluminal colonization related to insertion practices, while tunneled central lines have a longer duration of catheter placement and infections more likely occur through intraluminal routes due to increased hub manipulation and contamination (6). Overall, tunneled central lines have lower risks of infection than those that are non-tunneled. Other pathways for catheter-associated infections include seeding of the catheter from other infections already present in the body or, rarely, introduction of organisms through contaminated infusion fluids.

In 2008, the Centers for Medicare and Medicaid Services (CMS) announced that healthcare providers would no longer be receiving reimbursement for infections that were acquired during a patient's stay in the hospital. Patients with HAIs have a longer length of stay (LOS) in the hospital and need added therapy and care, and CLABSIs in ICUS have been associated with an increased LOS by an average of 10.4 days (4). The analysis also estimated that, on a per-case basis, CLABSI was the most expensive HAI, at $48,814 in additional costs. Through increased surveillance and prevention guideline implementation, CLABSI rates dropped 58% from 2001 to 2009; adding up to 3,000-6,000 potential lives saved, $414 million in potential excess healthcare costs saved in 2009, and over $1.8 billion in cumulative excess costs saved since 2001 (1).

Risk factors for the development of CLABSI have been previously identified and prevention practices, such as insertion procedure bundles and recommendations for selection of optimal line type and insertion site, have been adopted in order to address them. Two of the most commonly investigated risk factors are line type and line insertion site. A review of two hundred prospective studies found that the lowest incidence rates of infection were associated with the use of peripheral intravenous catheters and midline catheters (0.2-0.5 per 1000 catheter-days) and that

incidence rates for arterial catheters (used in hemodynamic monitoring) and peripherally inserted central catheters (used in hospitalized patients) were much higher (1.7-2.7 per 1000 catheter-days) (7). Surgically implanted long-term central venous devices, specifically cuffed and tunneled catheters and central venous ports, had incidence rates ranging from 0.1 to 1.6 per 1000 catheter-days. There are three common sites used to insert central venous catheters: the subclavian, jugular, and femoral veins. In a multicenter trial conducted by Parienti et al, the incidence rates of CLABSI in patients with a subclavian line were lower than those with jugular or femoral lines, respectively (1.5, 3.6, and 4.6 per 1000 catheter-days) (8). A 24 month prospective study also found similar results and documented that femoral sites were at greater risk of being colonized by coagulase negative staphylococci other than *S. epidermidis* compared to the subclavian and jugular sites combined (HR 4.15) (9). Additional identified risk factors include line dwell time, administration of parenteral nutrition, transfusion of blood products, number of lumens present, and changing the catheter with the use of a guidewire (6).

To standardize practice and reduce CLABSI incidence the CDC developed national guidelines for the prevention of intravascular catheter-related infections (10). The main focus of these recommendations are educating and training of personnel who insert and maintain lines, using aseptic technique throughout the procedure, appropriately choosing the line type and site in order to minimize the risk of complications, the preferred use of chlorohexidine as an antiseptic during line placements, and use of occlusive dressings throughout the period of maintenance of the lines (5, 10). In a collaborative prospective cohort study conducted among Michigan hospital adult ICUs in 2003, the mean rate of CLABSIs per 1000 catheter-days decreased from 7.7 at baseline to 1.4 at 16 to 18 months follow up ($P < .0001$) following the implementation of an intervention of five bundled procedures recommended by the CDC identified to have the greatest effect on CLABSIs and the lowest barriers to implementation (11). This procedure bundle consisted of hand washing, using full-barrier precautions during the insertion of central lines,

cleaning the skin with chlorohexidine, avoiding the femoral site when at all possible, and removing unnecessary catheters as soon as possible. It is now recommended that bundle strategies, documenting and reporting of compliance be implemented as performance improvement tactics (10, 12, 13). Department of Veterans Affairs hospitals in Denver, CO implemented a post-insertion bundle that resulted in in a decrease of the hospitals' CLABSI incidence rate from 5.7 per 1000 catheter-days during the pre-intervention period to 1.1 per 1000 catheter-days during the post-intervention period (13). The post-insertion bundle included daily inspection of the insertion site; site care if the dressing was wet, soiled, or had not been changed within 7 days; documentation of ongoing need for the catheter; proper use of a chlorohexidine sponge at the insertion site; proper hand hygiene prior to manipulation of the IV system; and use of an alcohol scrub to the hub for at least 15 seconds before each use.

While there has been extensive research conducted to identify risk factors associated with CLABSIs, and several studies focus on patients located in surgical ICUs, few to our knowledge have studied surgery as a potential risk factor. Hand sanitation before handling a central line is an important step in CLABSI prevention. During surgery, anesthesia providers often insert IVs and extensively manipulate IV systems in order to administer anesthetic agents. A study conducted at Dartmouth-Hitchcock Medical Center in 2008 explored the association between hand contamination of anesthesia providers and the risk of bacterial transmission in the operating room (OR) and found that 66% of anesthesiology staff had hands contaminated with one or more major pathogens (MRSA, VRE, methicillin-sensitive *S. aureus*, *Enterococcus*) at the end of surgery (14). Further, they identified intraoperative bacterial transmission to IV stopcocks in 11.5% of cases, almost half of which were of provider origin. A prior study conducted at Dartmouth-Hitchcock Medical Center reported transmission of bacterial organisms to intravenous stopcocks in 32% of cases (15). During surgery, it is also possible for bacteria introduced from the surgical wound to be transmitted to the bloodstream and eventually seeding infection on the catheter. In a

studying exploring the association between transfusions and CLABSIs at Emory University, surgery was found to be a significant factor (odds ratio=1.81, 95% CI [1.28, 2.55]; $p<0.0001$) (16).

Despite prevention efforts, there are a considerable number of CLABSIs occurring in hospitals and thus a need for further exploration of risk factors to help identify novel prevention efforts. This study attempts to address this need and assess the previously unaddressed relationship between CLABSIs and surgery.

Methods

Null Hypothesis

The rates of CLABSI are the same among patients with a central line who underwent surgery compared to those patients with a central line who did not undergo surgery.

Patient and Data Collection

This case-control study used data collected from the "Comparison of a Novel Silver-Coated Catheter Access Device and a Standard Access Device" study conducted at Emory University Hospital and Emory University Hospital Midtown in Atlanta, GA (17). To minimize bias and allow each hospital to serve as its own control, a crossover study design was used for the initial trial. It was completed over 18 months (November 2009 to June 2011) and included all patients over the age of 18 years old who were hospitalized at Emory University Hospital and Emory University Hospital Midtown and had a central venous catheter.

Using data in the initial study, cases of CLABSI were identified and matched to controls. Cases were defined using the National Healthcare Safety Network's (NHSN) surveillance definition for CLABSI. Data not included in the original study were pulled from patient records retrospectively. The study was granted approval from Emory University's Institutional Review Board (#00016682).

For this analysis, a case was defined as an inpatient with an NHSN-defined CLABSI, during the time period of December 2009 to June 2011, whose CLABSI was linked to the first central line in place during their hospitalization. To mitigate the chances of including patients with misdiagnosed CLABSIs, patients with mucosal barrier injuries were excluded from participation as cases (18). All patients admitted to a hospital unit, either ICU or ward, were considered inpatients. A control was defined as an inpatient who had a central line in place during the period of December 2009 to June 2011 and who was not diagnosed with a CLABSI throughout their hospital stay. In an effort to reduce possible bias, controls and cases were

matched using a ratio of 3:1 with central line type and an admission date within a range of 90 days set as matching criteria (19). Central line types were classified as central venous catheters (CVC), peripherally inserted central catheters (PICC), implanted ports, pulmonary artery catheters (PA catheters), and tunneled vascular access devices (VAD).

For this analysis, the primary outcome of interest was diagnosis of CLABSI. The primary exposure of interest was surgery occurring within 7 days prior to the development of CLABSI or line removal. Surgeries were limited to procedures that were classifiable under the NHSN Procedure Codes (20). Dwell time of the central line was considered to be the time at risk for consideration of other variables in the study. The hospital in which admission took place was also included as a variable.

In both cases and controls, only the first central line was included in the analysis. The site of insertion for each central line was classified as arm, femoral, internal jugular (IJ), and subclavian (SC). The "IJ" insertion site contains lines that were placed in the chest and tunneled to the internal jugular vein. Admission and discharge dates were pulled from patient's medical records and used to calculate the length of stay (LOS). The dwell time, or time at risk, was calculated from insertion dates and either discontinue or discharge date for controls or infection date for cases. Whether a line was placed in the OR was assessed by using ICD-9 coding. Age was assigned according to the patient's age at their date of admission, body mass index (BMI) was calculated using height and weight from patient medical records, and Charlson comorbidity index (CCI) was calculated using disease diagnoses from patient medical records (21). Also included in the analysis were dichotomous variables for diabetes, renal disease, receipt of hemodialysis, infusion of total parental nutrition (TPN), and transfusion of packed red blood cells while the central line was in place. Diabetes and renal disease status were ascertained from the CCI score breakdown.

Statistical Analysis

The distribution of demographic and clinical data was compared between cases and controls using X^2 and Wilcoxon-Mann-Whitney Z statistics. The crude relations between surgery status and CLABSI were analyzed using bivariate regression. Multivariate analysis included analysis of collinearity, interaction, and confounding. Throughout the multivariate analysis, collinearity was considered using a collinearity diagnostic macro. Condition indices (CDIs) and variance decomposition proportions (VDPs) were used to determine if a variable was affecting the reliability of the results secondary to collinearity. A variable with a CDI >2 or two VDPs equal to or greater than 0.5 was considered to have a high degree of collinearity. Due to collinearity, central line sites were excluded from analysis. In addition, due to collinearity and distribution, a new variable was created for CCI, classifying a patient as either having a score less than three or greater than or equal to three. Interaction terms including the main exposure and covariates found to be significant at alpha ≤ 0.2 in bivariate analysis were explored and none were found to be significant (Table 3) Subsequently, interaction terms for TPN and CCI score, TPN and hemodialysis, TPN and transfusion, transfusion and CCI score, transfusion and prior antibiotic use, and prior antibiotic use and CCI score were tested and also found to be non-significant. All interaction terms were excluded from consideration in a final model. Confounding was assessed next, using variables that were found to be significant in the bivariate analysis. The results from these analyses were used in the creation of a final model. Since conditional logistic regression was used, assessing goodness of fit for a model was not possible under statistical testing. Instead, several models were assessed using multiple elimination methods followed by comparing measures of precision of the primary exposure and other covariates. A final model was decided using backwards, stepwise, and forwards elimination, with inclusion criteria for consideration of variables being a p-value of ≤ 0.2 and < 0.1 for keeping a variable in the model, as well as biologic plausibility. For both backwards and stepwise model selection methods, the final model included surgery and CCI score. Forward selection yielded a model containing

surgery, CCI score, and prior antibiotic use. A model containing the results from backwards and stepwise selection with the addition of red blood cell transfusions was also considered (Table 4). Blood transfusion is a known CLABSI risk of interest and no significant precision was lost or gained from its inclusion in the model. The values for the main exposure of interest were similar between all models. The model containing surgery, CCI score, and blood transfusion was chosen as the final model (Table 5). Statistical analysis was completed using SAS version 9.4 (SAS Institute, Cary, NC).

Results

Within the original study time period from December 2009 through June 2011, 152 cases were identified as CLABSIs. Of those identified, 129 met the inclusion criteria for a case. During the same study time period, 18,290 inpatients met the criteria to act as a control. Out of the possible controls, 387 were randomly selected and matched to cases 3:1 based on admission month and year and line type. Three controls were matched for all of the cases.

Population demographics and characteristics for the 516 patients in the study population were generally similar between cases and controls (Table 1.) The study population consisted of 282 (55%) women and 234 (45%) men. The median participant age was 56 years and median BMI was 25.7 kg/m^2. Of those included in the study, 25 (4.8%) were underwent hemodialysis, 259 (50.2%) received the transfusion of blood products, and 157 (30.4%) had TPN while their first central line was in place. The median CCI score was 3, with almost 62 percent of all participants scoring greater than or equal to 3. Cases tended to have a longer median dwell time than controls (9 days vs. 5 days) and their length of stay after the removal of the first central line is also longer (9 days vs 0 days). Two hundred and ninety-one (75.2%) of the controls had lines removed on the day of discharge. None of the study participants had lines placed in the OR. Of all of the surgeries performed in the OR, the three most common surgery categories were exploratory laparotomies (23.0%), ventricular shunts (21.3%), and small bowel (16.4%). These surgeries were equally distributed between cases and controls.

The main exposure of interest in the analysis was whether or not a patient had surgery. Crude analysis between CLABSI and surgery showed that the development of CLABSI is associated with patients that had surgery (OR 2.46, 95% CI 1.38, 4.38) (Table 2). A crude association between CLABSI and prior antibiotic use (OR 6.0, 95% CI 1.81, 19.93), CLABSI and hemodialysis (OR 2.51, 95% CI 1.10, 5.74), and CLABSI and a CCI score of greater than or equal to three (OR 2.18, 95% CI 1.39, 3.42) also showed signification relationships. There did not

appear to be an association between CLABSI acquisition and blood transfusions, TPN administration, BMI, diabetes, or renal disease.

A multivariate model including surgery, facility, line site, blood transfusion, TPN use, antibiotic use prior to surgery, hemodialysis, and dichotomous CCI score was constructed. After assessing for collinearity, interaction, confounding, and precision, the final model included surgery, CCI and blood transfusion. Beyond showing the association between surgery and CLABSIs, the final model showed that a CCI score of 3 or greater independently predicted CLABSI (OR 2.34, 95% CI 1.46, 3.74) (Table 3).

Discussion

To our knowledge, this is one of few studies to look specifically at the relationship between surgery and CLABSIs among hospitalized patients. The results in this study indicate that surgery is a risk factor for developing CLABSI. We did not have the data necessary to make comparisons across different types of surgeries, but such data would allow for broader understanding of the relationship between surgery and CLABSIs and should be the next focus of study. None of the patients in the study had their primary central line inserted while they were in the OR, this may be in part due to the fact that central lines placed in the OR are not typically in place for extended periods. Antibiotic use prior to surgery was used as a surrogate for ongoing infection. Our sample size was very small (n=6) and thus the relationship between infection prior to surgery and CLABSI development could not be explored.

Transfusion of blood products and TPN have previously been reported as risk factors for CLABSI (16, 22). In our study they did not appear to be independent risk factors after controlling for surgery and comorbidities. In a study looking at blood product transfusion and CLABSI, the transfusion of packed red blood cells was significantly associated with CLABSI (16). Further, Hake's study determined that the amount of blood product transfused also contributed to the risk of CLABSI. We did not assess whether or not the significance of transfusion changed if we stratified by the quantity of packed red blood cells transfused while controlling for surgery and comorbidities. We saw that patients with higher composite CCI scores had greater risk of CLABSIs. A single hospital, retrospective study found that, while composite scoring did not have a significant effect on CLABSIs, individual comorbidities such as myocardial infarction and renal disease had a significant effect (23). This study had a small sample size (n=67) and could only generalize about some of the comorbidities that make up the CCI score. In our analysis we looked into renal disease and diabetes, but both were excluded from final consideration due to

confounding. The relationship between comorbidities, surgery, and risk of CLABSI warrants further exploration.

Previous studies have shown significant relationships between central line types and site of line placement and the development of CLABSI. There was a high degree of collinearity present in regards to central line characteristics, most probably due to our matching cases and controls based on line type. Due to this, we were unable to assess central line site together with central line type and risk for infection. Length of stay was not included in our analysis because extended stays appear to be an outcome of CLABSIs rather than a confounder. One limitation in our study was that it was retrospective and we were unable to populate some missing data elements, such as heights and weights needed to calculate BMI. Data collection was performed through a preexisting electronic database with limited supplemental collection of specific data elements from electronic medical records, but manual chart reviews were not performed.

Although this study had limitations, it is the most detailed look at the relationship between surgery in hospitalized patients with central lines. The lack of data exploring surgery and CLABSI makes it difficult to determine a causal relationship, but this study provides a starting foundation for future assessments of their association. A large prospective study focusing on CLABSI and surgery would help to expand on the results found here.

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Tables

Table 1. Participant Demographics and Clinical Characteristics

Variable	Total (n=516)	Cases (n=129)	Controls (n=387)	p-values
Median age, year [IQR]	56 (22.0)	57 (19.0)	55 (23.0)	0.47
Sex, n (%)				
Male	234 (45.4)	61 (47.3)	173 (44.7)	0.61
Median BMI [IQR]*	25.7 (9.1)	26.1 (10.3)	25.2 (8.4)	0.07
Hospital, n (%)				
Emory University Hospital	334 (64.7)	92 (71.3)	242 (62.5)	0.07
Emory University Hospital Midtown	182 (35.3)	37 (28.7)	145 (37.5)	
Line site, n (%)¤				
Arm	211 (41.6)	45 (35.2)	166 (43.8)	0.21
Femoral	18 (3.6)	5 (3.91)	13 (3.4)	
IJ	196 (38.7)	59 (46.1)	137 (36.2)	
Subclavian	82 (16.2)	19 (14.8)	63 (16.6)	
Line type, n (%)				
CVC	152 (29.5)	38 (25.0)	114 (75.0)	N/A
PA Catheter	4 (0.8)	1 (25.0)	3 (75.0)	
PICC	260 (59.4)	65 (25.0)	195 (75.0)	
Port	92 (17.8)	23 (25.0)	69 (75.0)	
Tunneled VAD	8 (1.6)	2 (25.0)	6 (75.0)	
Median Dwell Time, days [IQR]	6.0 (7.0)	9.0 (8.0)	5.0 (7.0)	**<.0001**
Surgery, n (%)				
Yes	61 (11.8)	25 (19.4)	36 (9.3)	**0.0022**
Median Charlson Comorbidity Index (CCI), score [IQR]	3.0 (4.0)	4.0 (5.0)	3.0 (3.0)	**<.0001**
CCI Category, n (%)				
Score ≥ 3	321 (62.2)	97 (75.2)	224 (57.9)	**0.0004**
Score < 3	195 (37.8)	32 (24.8)	163 (42.1)	
Diabetes¢, n (%)				
Yes	149 (28.9)	45 (34.9)	104 (26.9)	0.08
Renal Disease¢, n (%)				
Yes	123 (23.8)	33 (25.6)	90 (23.3)	0.59
TPN, n (%)				
Yes	157 (30.4)	46 (35.7)	111 (28.7)	0.14
Transfusion, n (%)				
Yes	259 (50.2)	73 (56.6)	186 (48.1)	0.09
Hemodialysis, n (%)				
Yes	25 (4.8)	11 (8.5)	14 (3.6)	**0.0246**
Antibiotics given 24 hours - 7 days prior to surgery, n (%)				
Yes	12 (2.3)	8 (6.2)	4 (1.0)	**0.0025**
Median Length of Stay, days [IQR]	10.0 (14.0)	21.0 (14.0)	8.0 (10.0)	**<.0001**
Median Stay after Line 1 Removal, days [IQR]	0.0 (7.0)	9.0 (10.0)	0.0 (0.0)	**<.0001**

*BMI has 45 observations missing

¤ Line site has 9 missing

¢ Determined from CCI score

BMI: body mass index

IJ: internal jugular

CVC: central venous catheter

PA Catheter: pulmonary artery catheter

PICC: peripherally inserted central catheter

TPN: total parenteral nutrition

Tunneled VAD: tunneled venous access device

Table 2. Crude Odds Ratio of Covariates Predicting Central Line-associated Bloodstream Infection

BIVARIATE ANALYSIS			
Variable	OR	95% CI	p-value
Surgery	2.46	(1.38, 4.38)	**0.0023**
Hospital	1.49	(0.97, 2.29)	0.07
Line Site			
Arm	0.63	(0.30, 1.31)	**0.0279**
Femoral	1.6	(0.48, 5.31)	
IJ	1.69	(0.90, 3.20)	
Subclavian	(REF)		
Transfusion	1.46	(0.96, 2.22)	0.08
TPN	1.39	(0.90, 2.13)	0.14
Antibiotics	6	(1.81, 19.93)	**0.0034**
Hemodialysis	2.51	(1.10, 5.74)	**0.0291**
BMI	1.01	(0.99, 1.04)	0.33
CCI	1.15	(1.08, 1.22)	**<.0001**
CCI Categories			
Score ≥ 3	2.18	(1.39, 3.42)	**0.0007**
Score < 3	(REF)		
Diabetes	1.47	(0.96, 2.31)	0.08
Renal Disease	1.14	(0.71, 1.82)	0.59

CCI: Charlson comorbidity index

CI: confidence interval

IJ: internal jugular

OR: ods ratio

TPN: total parenteral nutrition

Table 3. Interaction of Covariates for Predicting the Association of Central Line-associated Bloodstream Infections

Interaction Variables	Chi-Square	p-value
Surgery*Transfusion	0.93	0.3342
Surgery*TPN	2.16	0.1421
Surgery*Hemodialysis	0.33	0.5658
Surgery*CCI score	0.60	0.4381
TPN*CCI score	0.01	0.9080
Transfusion*CCI score	0.23	0.6337
Antibiotics*CCI score	3.21	0.0731
Antibiotics*Transfusion	0.00	0.9702
Transfusion*TPN	2.25	0.1333
TPN*Hemodialysis	0.58	0.4467
Transfusion*Hemodialysis	1.18	0.2769

CCI: Charlson comorbidity index

TPN: total parenteral nutrition

Table 4. Potential Models for the Outcome of Central Line-associated Bloodstream Infections Using Conditional Logistic Multivariate Regression

Model	OR	95% CI
#1		
Surgery	2.85	(1.57, 5.17)
CCI ≥ 3	2.40	(1.51, 3.82)
#2		
Surgery	2.19	(1.10, 4.35)
CCI ≥ 3	2.36	(1.48, 3.76)
Antibiotics	2.96	(0.75, 11.75)
#3		
Surgery	2.69	(1.47, 4.93)
CCI ≥ 3	2.39	(1.50, 3.81)
Transfusion	1.32	(0.85, 2.03)

CCI: Charlson comorbidity index

CI: confidence interval

OR: odds ratio

Table 5. Final Model for Central Line-associated Bloodstream Infections

Final Model	CLABSI=SURGERY + (CCI ≥ 3) + TRANSFUSION	
	OR (95% CI)	p-value
Surgery	2.69 (1.47, 4.93)	0.0013
CCI ≥ 3	2.39 (1.50, 3.81)	0.0003
Transfusion	1.32 (0.85, 2.03)	0.2174

CCI: Charlson comorbidity index