Published in final edited form as:

Am J Crit Care. 2016 December ; 26(1): 43–52. doi:10.4037/ajcc2017220.

Risk Factors for Bacteremia in Patients With Urinary Catheter-Associated Bacteriuria

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Abstract

Background—Catheter-associated bacteriuria is complicated by secondary bacteremia in 0.4% to 4.0% of cases. The directly attributable mortality rate is 12.7%

Objective—To identify risk factors for bacteremia associated with catheter-associated bacteriuria.

Methods—Data were acquired from a large electronic clinical and administrative database of consecutive adult inpatient admissions to 2 acute care hospitals during a 7-year period. Data on patients with catheter-associated bacteriuria and bacteremia were compared with data on control patients with catheter-associated bacteriuria and no bacteremia, matched for date of admission plus or minus 30 days. Urine and blood cultures positive for the same pathogen within 7 days were used to define catheter-associated bacteriuria and bacteremia. Multivariable conditional logistic regression was used to determine independent risk factors for bacteremia.

Results—The sample consisted of 158 cases and 474 controls. Independent predictors of bacteremia were male sex (odds ratio, 2.76), treatment with immunosuppressants (odds ratio, 1.68), urinary tract procedure (odds ratio, 2.70), and catheter that remained in place after bacteriuria developed (odds ratio, 2.75). Patients with enterococcal bacteriuria were half as likely to become bacteremic as were patients with other urinary pathogens (odds ratio, 0.46). Odds of

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secondary bacteremia increased 2% per additional day of hospital stay (95% CI, 1.01-1.04) and decreased 1% with each additional year of age (95% CI, 0.97-0.99).

Conclusions—The results add new information about increased risk for bacteremia among patients with catheters remaining in place after catheter-associated bacteriuria and confirm evidence for previously identified risk factors.

Urinary catheters are common in the intensive care unit (ICU); 50% to 80% of adult ICU patients have a urinary catheter in place.¹ During the first week of catheterization, bacteriuria develops in 8% of patients per day, and after the 10th day of catheterization, half of patients are bacteriuric.² Such catheter-associated bacteriuria (CAB) can result in marked morbidity, mortality and cost, particularly if complicated by bacteremia. Prospective studies³⁻⁵ have indicated that 0.4% to 4% of patients with CAB become bacteremic. The mortality rate directly attributable to hospital-acquired bacteremic CAB is 12.7%.⁶ In an estimate published in 2000, the cost of bacteremic CAB was \$2836 per episode.⁴

Little evidence is available to help clinicians identify which patients with CAB are at risk for bacteremia. The results of a few studies⁷⁻⁹ suggest that patients who have received immunosuppressant medications or red blood cell transfusion; smokers; and patients with neutropenia, malignant neoplasms, liver disease, diabetes, or underlying renal disease may be at increased risk. However, evidence is conflicting for some risk factors, and only single studies have been done on other risk factors. Whether or not leaving a catheter in place after the onset of bacteriuria affects the risk for subsequent bacteremia has not been examined.¹⁰ Identifying patients at high risk for bacteremia would enable clinicians to target those patients for interventions such as early catheter removal or use of alternatives such as intermittent catheterization.¹¹ Distinguishing patients at low risk for bacteremia could reduce inappropriate use of antimicrobial agents for asymptomatic bacteriuria.¹² Our aim therefore was to determine risk factors for secondary bacteremia among adult patients with nosocomial CAB.

Methods

We used a matched case-control design and compared case patients with nosocomial CAB and concurrent bacteremia with control patients with nosocomial CAB without bacteremia. Three controls were randomly selected from among all patients with CAB who were admitted within 30 days before or after the case patient. Cases and controls were matched on admission date to account for any unmeasured changes in clinical care that occurred over time, such as culturing practices or catheter materials used.

Setting and Sample

Data were obtained from a large database that merged electronic clinical and administrative data for the years 2006 through 2012 from all inpatient admissions to an academic medical system in the northeastern United States.¹³ All consecutive admissions of patients more than 18 years old to 2 hospitals were included. Facility A is a 300-bed community hospital, and facility M is a 745-bed tertiary care hospital. Approval for the study, with a waiver of individual consent, was obtained from the appropriate institutional review board.

Measures

Results of clinical cultures were used for the study. Nosocomial CAB was defined as a urine culture positive for bacteria on or after hospital day 3 in a patient who had had no previous positive urine culture during the admission and who had an indwelling urethral catheter in place on the date of the culture or within 72 hours before the culture. A urine culture was considered positive if it had either of the following: more than 105 colony-forming units per milliliter of urine with no more than 2 species of microorganisms or fewer than 105 colony-forming units per milliliter of urine with no more than 2 species of microorganisms and pyuria (> 3 pus cells per high-powered field) within 48 hours before or after the positive culture. Our definitions were designed to be as similar as possible to definitions of catheter-associated urinary tract infection in use at the time by the National Healthcare Safety Network.¹⁴ Only the first episode of CAB was included for each patient. Urinary catheter care and methods for collecting urine specimens at the participating hospitals are explained further in Appendix 1.

Concurrent bacteremia was defined as growth of the same species from a blood culture taken within 7 days after a positive urine culture in a patient who had had no previous blood cultures positive for the same organism during the same admission. Pathogens were identified and sensitivity to antimicrobial agents was determined by using conventional microbiological methods. Because the 2 study hospitals were part of a single large health system, their policies for specimen collection and laboratory processing were the same. Methods for culturing blood and urine specimens and for susceptibility testing methods used at the participating hospitals are explained further in Appendix 2.

The Charlson Comorbidity Index¹⁶ was used to measure comorbid conditions in the aggregate at the time of admission. The presence or absence of diabetes mellitus, malignant neoplasm, and urinary tract disease was determined by using primary or secondary *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)*¹⁷ codes with present on admission indicators. Electronic records of medications administered were used to ascertain whether or not a patient received antimicrobial agents within 3 days before CAB; immunosuppressants, including steroids, up to 14 days before CAB; or hydroxy-methylglutaryl coenzyme A reductase inhibitors (statins) within 6 weeks before CAB during the current admission. *ICD-9-CM* procedural codes 55 through 59 were used to determine whether or not a patient had undergone a urinary tract procedure or surgery at any time during the patient's admission. If insertion of a urinary catheter was assigned an *ICD-9-CM* code, the insertion was included among urinary tract procedures.

Age, sex, facility, and length of stay were determined by using electronic administrative data. Number of days of catheterization before CAB was calculated by using the electronic clinical record for cases and controls. The source of catheter information was Eclipsys (Eclipsys Corp) data fields completed by nurses. Times of catheter placement and removal were stamped on the electronic health record. Patients who had catheter insertion and removal dates recorded were included in the study. Information was not available on the types of catheters, catheter placement method or location, catheter care procedures, or the number of days of catheterization before admission.

To assess the effect of leaving a catheter in place after CAB onset on the risk for bacteremia, we determined whether a catheter was present or absent on the day of bacteremia in the cases, and after an equivalent period of time in the matched controls. Thus, if bacteremia developed in a case patient 2 days after CAB, we looked for the presence or absence of a catheter in the matched control patients 2 days after the control patient's CAB date.

Data Analysis

Descriptive statistics were computed for cases and controls separately, including means and standard deviations or medians and interquartile ranges for continuous variables, and frequencies and percentages for categorical variables. Simple and multivariable conditional logistic regression models were constructed. The outcome bacteremia was regressed on each of the risk variables in simple logistic models. Any variable with a *P* of .25 or less or that was clinically significant was entered into a preliminary multivariable model,¹⁸ and any variable with a *P* greater than .05 that was not a confounder in the preliminary model was removed. Analyses were performed by using SAS 9.3 software (SAS Institute).

Results

During the study period, 158 cases of CAB with secondary bacteremia occurred. Approximately half (53%) of the cases had urine and blood cultures positive on the same day. Three controls were identified for each case, bringing the total sample to 632 patients. The distributions of risk factors among cases and controls are listed in Table 1. Cases were younger than controls (median age, 66 vs 70 years; *P* = .03) but had a higher score on the comorbidity index (3 vs 2; *P* = .02). The proportion of males was higher among cases than among controls (58.9% vs 34.8%; *P* < .001); the percentage of patients with malignant neoplasm (28.5% vs 17.9%; *P* = .005) was also higher. More cases than controls received antimicrobial agents before CAB (48.7% vs 34.8%; *P* = .002) and immunosuppressants before CAB (41.8% vs 26.6%; *P* < .001). Urinary tract procedures were more common among cases than among controls (10.8% vs 3.8%; *P* = .001). Cases had a longer hospital stay (10 days vs 7 days; *P* < .001) and had catheters in place for longer periods before CAB than did controls (8 vs 4 days; *P* < .001).

More case patients had catheters in place at the time of bacteremia than did control patients at an equivalent time period (79.1% vs 56.1%; *P* < .001). To illustrate this point further, the Figure shows the percentage of cases and controls with a catheter left in place after CAB developed. The number of case patients in whom bacteremia developed and their matched controls were removed from the denominator for subsequent days. On the day of a positive urine culture (day 0), 84% of cases and 68% of controls had a catheter in place. On subsequent days, more than 70% of cases in whom bacteremia had not yet developed still had a catheter in place, whereas the proportion of the matched controls with a catheter in place was steadily declining.

A single organism was responsible for CAB in most patients (96%). Table 2 lists causative organisms for CAB and bacteremia. The most common urinary pathogens were Enterobacteriaceae (*Escherichia coli*, 34.2%; *Klebsiella pneumoniae*, 17%) and *Enterococcus* species (*Enterococcus faecalis*, 14%; *Enterococcus faecium*, 5.5%). CAB

caused by *Klebsiella* was more common among case patients than among control patients (27% vs 16%; $P = .005$), and enterococcal CAB was less common among cases than among controls (14% vs 23%; $P = .02$). The proportion of resistant urinary pathogens did not differ significantly between cases and controls (10% vs 9%).

Results of a conditional logistic regression model are displayed in Table 3. Duration of catheterization and length of stay were collinear; therefore, only length of stay was included in the model. The final model included age, sex, value on the Charlson Comorbidity Index, diabetes, malignant neoplasm, urinary tract disease, treatment with immunosuppressants, urinary tract procedure, *Enterococcus* in the urine, *Klebsiella* in the urine, length of stay before CAB, and catheter in place after CAB. With controls for other factors in the model, the odds of bacteremia were more than 2.5 times higher for males than for females (odds ratio [OR], 2.76; 95% CI, 1.80-4.21), for patients who underwent a urinary tract procedure (OR, 2.70; 95% CI, 1.09-6.74), and for those with a catheter left in place (OR, 2.75; 95% CI 1.65-4.56). Patients treated with immunosuppressants had 1.68 times the odds for development of bacteremia (95% CI, 1.06-2.66). Patients with enterococcal CAB were half as likely to become bacteremic compared with patients with CAB caused by other genera (OR, 0.46; 95% CI, 0.25-0.83). The odds for development of secondary bacteremia increased 2% per additional day of stay in hospital before the onset of CAB (95% CI, 1.01-1.04) and decreased 1% with each addition year of age (95% CI, 0.97-0.99).

Discussion

Our results indicated several independent predictors of bacteremia in patients with CAB: younger age, male sex, treatment with an immunosuppressant, urinary tract procedure, nonenterococcal CAB, longer hospital stay before onset of CAB, and having a catheter in place after CAB developed. These findings reinforce the results of previous research and also indicate that the presence of a catheter is a risk factor.

We found a 1% decrease in the risk for bacteremia with each additional year of age. This finding is puzzling because it contradicts theories of immunosenescence.¹⁹ However, it is consistent with findings from 2 previous case-control studies^{7,9} on risks for nosocomial urinary tract-related bacteremia. In the study by Greene et al,⁹ case patients were significantly younger than control patients in unadjusted analysis. In the other study,⁷ diabetes and steroid use were predictors of bacteremia in patients less than 70 years old. Despite the general perception that older persons are more vulnerable than younger persons to infection, in a recent study²⁰ of a national random sample of hospitalized adults, age was not related to overall rates of health care-associated infections after adjustments were made for other demographic characteristics, device use, and common comorbid conditions. Furthermore, in 2 recent hospital studies²¹⁻²³ in which rates of health care-associated infections were higher among patients more than 65 years old, urinary catheterization was significantly higher among the elderly. Possibly, by sampling data for catheterized patients only, we eliminated a confounding influence not controlled for in earlier work. The relationship between age and risk of infection warrants more research.

Although women are at increased risk for CAB,²⁰ men are at increased risk for bacteremia associated with CAB.^{7,9,23} In our study, the odds of bacteremia were 2.8 times higher for men, supporting the earlier results. In a related study,²⁴ men were also at increased risk for surgical site infection and primary bloodstream infection (ie, bacteremia without cultures positive for the same organism from another body site). The increased risk for bacteremia associated with CAB in men compared with women may be due to hormonal differences, differences in genitourinary anatomy, the indication for catheterization (eg, obstruction), or differences in the urinary microbiota between the sexes.²⁵ These potential underlying mechanisms deserve further investigation.

Not surprisingly, we found that patients treated with immunosuppressants were at increased risk for bacteremia compared with patients who were not given such medications, confirming earlier evidence.^{7,9} Also as expected, we found that patients with CAB who underwent urological procedures were at increased risk for bacteremia. Previous studies^{9,26,27} have indicated that procedures, such as transurethral prostate resection, that injure the mucosal barrier promote translocation of pathogens to the bloodstream, increasing the chance of bacteremia and sepsis.

The prevalence of urinary pathogens and the proportion of resistant organisms in our study were similar to the prevalence reported in 2009 through 2010 to the National Healthcare Safety Network for symptomatic and bacteremic urinary tract infection.²⁸ The 4 most common pathogens identified in our study were among the top 5 most common urinary pathogens reported to the network.²⁹ Drug resistance was not a predictor of bacteremia in our study. This finding confirms the results of a previous prospective study²⁹ in which bacteremia outcomes did not differ between patients with bacteriuria caused by vancomycin-resistant enterococci and patients with bacteriuria due to vancomycin-sensitive enterococci.

We did find that the odds of bacteremia were 54% lower in patients with CAB caused by enterococci compared with other pathogens. This finding is in contrast to the results of earlier case-control studies^{7,9} in which the urinary pathogen was not predictive of bacteremia after adjustments were made for other factors. Similarly, in a large prevalence study³⁰ of nosocomial CAB in hospitalized urology patients across Europe and Asia, enterococcal infections were no less likely to be manifested as urosepsis than were infections caused by other pathogens. One explanation for our finding might be that enterobacteria are more likely than other microorganisms to elicit a febrile response and prompt physicians to obtain blood cultures. Thus, enterococcal bacteremias may have been less frequently detected.

Our results suggest that longer hospital length of stay before development of CAB increases risk for bacteremia, reinforcing previous research.⁷ Length of stay before CAB may be indicative of a patient's severity of illness; if so, intuitively, bacteremia may be more likely to develop in patients who have been in the hospital longer.

To our knowledge, our study is the first on the influence of the continued presence of a urinary catheter on the risk for bacteremia in patients with CAB. Compared with patients whose catheters were removed, patients with a catheter left in place after the onset of CAB,

taking into account age, sex, comorbid conditions, medications, procedures, pathogen, and length of stay, had higher odds of bacteremia. An association is plausible, because urinary catheters acquire biofilms that insulate pathogens physically and slow microbial replication, minimizing the effects of antimicrobial drugs.³¹ Also, latex and silicone can cause inflammation and disruption of the cell membranes of urothelial cells in the presence or absence of bacteria in vitro.^{32,33} The physical and chemical irritation of the bladder epithelium by catheters may promote translocation of pathogens from the urine into the bloodstream. However, our sample of patients with catheters remaining in place might have been more acutely ill than those whose catheters were removed. Although we controlled for comorbid conditions by using the Charlson Comorbidity Index, we could not control for severity of illness at the time of CAB; thus, the presence of a catheter may be an indication of a patient's severity of illness. In addition, patients with chronic indwelling urethral catheters might have been overrepresented in the group of patients with a catheter remaining in place after CAB. Because we did not identify which patients had catheters present at the time of admission, we cannot rule out possible mediating effects of chronic catheterization on the risk for bacteremia.

Our results did not support findings that the following comorbid conditions increased the odds for bacteremia in patients with CAB: malignant neoplasm,⁷ urinary tract disease,⁹ diabetes,⁷ and higher Charlson Comorbidity Index.³⁴

Limitations

Our study had several limitations. First, because the data were retrospective, the quality of the measures may be imperfect (eg, coding of comorbid conditions may have been incomplete, or clinical specimens may have been collected incorrectly). The quality of catheter data is especially important to our results. Patients were only included in the study if they had catheter placement and removal dates recorded. We are confident that times of catheter placement were accurately recorded, because the use of catheters at our study hospitals (34% of admissions, data not shown) is similar to the 31% catheter utilization rate recorded in published reports.³⁵ However, if catheter removal dates were systematically missed, the subpopulation of patients who had the devices removed would be underrepresented in our study. Second, a misclassification bias is possible. Patients classified as having had a urological procedure may have undergone the procedure after the onset of CAB and the 7-day follow-up period. This misclassification of exposure would have been nondifferential, thus biasing results toward the null. Also, we drew our control patients from among all patients without a blood culture positive for microorganisms. Hence, our pool of controls may have included patients who had clinical signs of sepsis but did not have blood samples obtained for culturing or had blood cultures negative for microorganisms because of collection or culturing techniques, timing, or administration of antibiotics. In effect, we may have compared cases of bacteremia with cases of sepsis. In post hoc analysis with *ICD-9-CM* codes for sepsis, severe sepsis, and septic shock, we found that 41% of cases and only 7% of controls had sepsis during their hospitalization (data not shown), reassuring us that misclassification, if it occurred, was minimal. Third, unmeasured factors such as smoking, genetic predisposition to infection, or blood transfusion history may have confounded our results. Transfusion of red blood cells has a strong, dose-dependent effect on risk for urinary

tract-related bacteremia,⁸ and restricting transfusions lowers the risk for health care-associated infections.³⁶ Finally, the sample consisted of data on patients from 2 hospitals in a metropolitan academic medical system, so results may not be generalizable to patients in small or rural hospitals.

Implications

Despite the limitations, our findings are useful for informing clinical practice. Men with urinary catheters remaining in place after the onset of CAB, who are receiving immunosuppressants, who have had a urinary tract procedure, or who have been in the hospital for a prolonged period should be considered at high risk for bacteremia. These patients should be targeted for early catheter removal or replacement or use of an alternative such as intermittent catheterization.¹¹ Suprapubic catheterization could be considered for short-term bladder drainage in adults with multiple risk factors for CAB.¹¹ An external device (condom drainage) may be a useful alternative for cooperative male patients without outlet obstruction. Although episodes of bacteriuria may not be reduced with the use of an external device,³⁷ switching from an indwelling to an external catheter will remove one of the risk factors for associated bacteremia.

Our findings also may help reduce inappropriate use of antimicrobial agents by distinguishing patients with CAB who are at low risk for bacteremia. Urinary tract infection is the second most common indication for use of antimicrobial agents in hospitalized patients.³⁸ Despite expert recommendations against treatment for most asymptomatic infection, 32% of patients with asymptomatic CAB are inappropriately treated.^{12,37} Distinguishing risk factors for bacteremia, as we have done, may encourage clinicians to refrain from treating asymptomatic CAB in patients without risk factors.

Conclusions

Our findings provide new information about the increased risk for bacteremia among patients with catheters remaining in place after the onset of CAB and add important confirmatory evidence for previously identified risk factors for bacteremia, including male sex, treatment with immunosuppressants, urinary tract procedures, and prolonged hospital stay. Patients with CAB caused by enterococci appear to be at lower risk for bacteremia than are patients with CAB caused by other urinary pathogens. Research is needed to clarify the independent effects of age on risk for bacteremia after CAB.

Acknowledgments

FINANCIAL DISCLOSURES

Laurie J. Conway was supported by Ruth L. Kirschstein National Research Service Award F31 NR014063, National Institute of Nursing Research.

Appendix 1: Urinary Catheter Care and Specimen Collection

The policies for nursing care of patients with indwelling urinary catheters at the participating hospitals during the study period were as follows: Urinary catheters were inserted only when

necessary and were removed as soon as possible. Intermittent catheterization was promoted as preferable to use of an indwelling catheter. Appropriate indications for use of indwelling catheters included treating urinary retention that could not be treated by other methods, such as an intermittent catheterization or medication; measurement of urine volume in critically ill patients, such as those with renal failure; patients with stage 3 or stage 4 pressure ulcers of the trunk; and palliative care patients at the end of life. After 2008, nurses began evaluating patients' ongoing need for a catheter every shift. Indwelling catheterization was avoided during treatment of urinary tract infection if possible.

Hand hygiene was performed before and after catheter insertion, manipulation, irrigation, emptying of drainage bag, and collection of specimens. A closed, sterile system was maintained, and the tamper-evident seal on preconnected systems was monitored. Catheters were secured to the patient's thigh in a manner that avoided tension or tugging, and patients were instructed not to pull or tug on the catheter. Leg bags were used when possible to allow the patients greater mobility. Drainage bags were kept to gravity but off the floor. Ambulatory patients were instructed to avoid raising the drainage bag above the bladder level to prevent the reflux of urine. After 2008, the policy was to empty urine collection bags before patient transport to avoid reflux of urine back into the patient's bladder during transfers. Drainage bags were emptied every 8 hours and as needed in a manner that avoided contact between the drainage spigot and the nonsterile collecting container. A separate collecting container was used for each patient (and after 2008, a separate container was used for each drainage device in a patient with more than 1 such device). The patient's perineum was cleansed daily, after each bowel movement, and as needed with soap and water. Patients were instructed in self-care if applicable. Patients with unrestricted fluid intake were encouraged to increase their fluid intake to at least 3 L/d.

Indwelling catheters were not changed at arbitrary fixed intervals. Instead, catheters were changed at the first indications of infection, mechanical obstruction, or leakage. Strict aseptic technique was used, and the entire system was changed at the same time. Patients were assessed daily for signs and symptoms of infection such as cloudy malodorous urine; complaints of suprapubic, back, or flank pain; and elevations in temperature or white blood cell count. Culturing of urine specimens was performed as ordered.

An order from a physician, nurse practitioner, or physician assistant was required to collect urine for culture. Specimens were collected by registered nurses or by nursing attendants or patient care technicians as instructed by a licensed professional. Hand hygiene was performed before and after specimen collection, and gloves were used during the procedure. The catheter drainage tube was clamped with a padded hemostat a minimum of 7.62 cm (3 in) below the sample port until the urine was visible under the catheter sample port puncture site. The surface of the puncture site was cleansed with an alcohol wipe. A 22-gauge needle was inserted at an angle through the center of the puncture site, and urine was aspirated into a 10-mL syringe. (After August 2011, needleless syringes were used to aspirate urine from the sample port by using an aseptic technique.) The urine was transferred to a labeled specimen cup and placed in a sealed bag. Specimens were placed in a specimen refrigerator until transport to the laboratory.

Appendix 2: Urine and Blood Culture and Susceptibility Testing Methods

Urine Cultures

All urine specimens were inoculated onto 5% sheep blood agar and MacConkey agar plates (BBL) by using calibrated loops that deliver 0.001 μ L of sample. Plates were incubated at 35°C in ambient air for 18 to 24 hours before being examined by a medical technologist.

The following gram-negative rods were identified in accordance with the Abbreviated Identification of Bacteria and Yeast; Approved Guideline—Second Edition of the Clinical and Laboratory Standards Institute¹⁵: *Escherichia coli*, *Proteus* species, and *Pseudomonas aeruginosa*. All other gram-negative rods were identified by using the VITEK 2 microbial identification system (bioMérieux).

For all gram-negative rods, antimicrobial susceptibility testing was performed by using the VITEK 2 microbial identification system (bioMérieux). Identification and susceptibility testing for all gram-positive organisms were performed by using the MicroScan WalkAway system (Beckman Coulter, Inc).

Blood Cultures

Blood culture bottles (Bactec Plus Aerobic, Plus Anaerobic Lytic, and Peds Plus) were loaded onto the BD Bactec FX blood culture system (Becton, Dickinson, and Co) within 30 minutes of arriving in the laboratory. Bottles were incubated at 35°C for up to 5 days before results were finalized as negative for microorganisms. A sensor identifies bottles positive for microorganisms by detecting fluorescent carbon dioxide captured by a filter on the bottom of the bottle. Positive bottles are worked up 24/7.

Contents of positive blood culture bottles were inoculated onto 5% sheep blood agar, chocolate agar, and MacConkey agar plates (BBL) via a venting needle. If the anaerobic bottle was positive, a battery of anaerobic media was included. If yeast was observed on the Gram stain, CHROMagar candida and Sabouraud dextrose agar plates were added. Plates were incubated at 35°C in ambient air for 18 to 24 hours before being examined by a medical technologist. Anaerobic media were incubated under anaerobic conditions, and plates were examined at 48 hours.

The following gram-negative rods were identified in accordance with the Abbreviated Identification of Bacteria and Yeast; Approved Guideline—Second Edition¹⁵: *Escherichia coli*, *Proteus* species, and *Pseudomonas aeruginosa*. All other gram-negative rods, as well as yeast, were identified by using the VITEK 2 microbial identification system (bioMérieux).

For all gram-negative rods, antimicrobial susceptibility testing was performed by using the VITEK 2 microbial identification system. Identification and susceptibility testing for all gram-positive organisms were performed by using the MicroScan WalkAway system (Beckman Coulter, Inc).

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Figure.

Percentage of cases and controls with a catheter in place after catheter-associated bacteriuria (CAB). Cases and their matched controls were removed from the denominator for days subsequent to the onset of bacteremia in the case patient. CAB developed within 72 hours after catheter removal in 16% of cases and 32% of controls.

Table 1

Frequencies of risk factors for bacteremia among cases and controls with catheter-associated bacteriuria (CAB)

Variable ^a	Cases (n = 158)	Controls (n = 474)	P ^b
Age, median (IQR), y	66 (52-77)	70 (58-80)	.009
Male sex	93 (58.9)	165 (34.8)	<.001
Charlson Comorbidity Index, median (IQR)	3 (1-5)	2 (1-4)	.02
Diabetes mellitus	36 (22.8)	139 (29.3)	.11
Malignant neoplasm	45 (28.5)	85 (17.9)	.005
Urinary tract disease	92 (58.2)	254 (53.6)	.31
Antimicrobial agent within 3 days before CAB	77 (48.7)	165 (34.8)	.002
Immunosuppressant within 14 days before CAB	66 (41.8)	126 (26.6)	<.001
Statin within 6 weeks before CAB	58 (36.7)	194 (40.9)	.35
Urinary tract procedure	17 (10.8)	18 (3.8)	.001
Resistant organism in urine ^c	16 (10.1)	41 (8.6)	.57
Two organisms in urine	4 (2.5)	22 (4.6)	.35
<i>Enterococcus</i> in urine	22 (13.9)	107 (22.6)	.02
<i>Escherichia</i> in urine	56 (35.4)	169 (35.7)	.96
<i>Klebsiella</i> in urine	42 (26.6)	78 (16.5)	.005
Facility A (vs M)	20 (12.7)	50 (10.6)	.46
Length of stay before CAB, median (IQR)	10 (5-22)	7 (5-12)	<.001
Catheter days before CAB, median (IQR)	8 (3-20)	4 (2-8)	<.001
Catheter in place after CAB	125 (79.1)	266 (56.1)	<.001

Abbreviation: IQR, interquartile range.

^aFrequencies in second and third columns are number (percentage) of patients unless otherwise stated in the first column.

^bP values determined by Mann-Whitney test for continuous variables and χ^2 or Fisher exact test for categorical variables.

^cResistant organisms included extended-spectrum β -lactamase Enterobacteriaceae, methicillin-resistant *Staphylococcus aureus*, and vancomycin-resistant enterococci. No carbapenem-resistant organisms were isolated.

Table 2

Drug-sensitive and drug-resistant causative organisms for catheter-associated bacteriuria (CAB) and secondary bacteremia among 632 hospitalized adults

Organism ^a	No. (%) of patients					
	Urine (n = 658) ^b			Blood (n = 158)		
	Sensitive	Resistant ^c	Total	Sensitive	Resistant ^c	Total
<i>Escherichia coli</i>	213 (32.4)	12 (1.8)	225 (34.2)	52 (32.9)	3 (1.9)	55 (34.8)
<i>Klebsiella pneumoniae</i>	109 (16.6)	3 (0.5)	112 (17.0)	39 (24.7)	1 (0.6)	40 (25.3)
<i>Enterococcus faecalis</i>	85 (12.9)	7 (1.1)	92 (14.0)	11 (7.0)	2 (1.3)	13 (8.2)
<i>Pseudomonas aeruginosa</i>	43 (6.5)	0	43 (6.5)	9 (5.7)	0	9 (5.7)
<i>Enterococcus faecium</i>	4 (0.6)	32 (4.9)	36 (5.5)	1 (0.6)	8 (5.1)	9 (5.7)
<i>Proteus mirabilis</i>	35 (5.3)	0	35 (5.3)	4 (2.5)	0	4 (2.5)
<i>Enterobacter cloacae</i>	18 (2.7)	0	18 (2.7)	5 (3.2)	0	5 (3.2)
<i>Morganella morganii</i>	12 (1.8)	0	12 (1.8)	1 (0.6)	0	1 (0.6)
<i>Citrobacter koseri</i>	11 (1.7)	0	11 (1.7)			
<i>Staphylococcus aureus</i>	6 (0.9)	4 (0.6)	10 (1.5)	5 (3.2)	2 (1.3)	7 (4.4)
<i>Enterobacter aerogenes</i>	9 (1.4)	0	9 (1.4)			
<i>Serratia marcescens</i>	9 (1.4)	0	9 (1.4)	3 (1.9)	0	3 (1.9)
<i>Citrobacter freundii</i>	8 (1.2)	0	8 (1.2)	1 (0.6)	0	1 (0.6)
<i>Klebsiella oxytoca</i>	8 (1.2)	0	8 (1.2)	1 (0.6)	0	1 (0.6)
Other	30 (4.6)	0	30 (4.6)	10 (6.3)	0	10 (6.3)
Total	600 (91.2)	58 (8.8)	658 (100.0)	142 (89.9)	16 (10.1)	158 (100.0)

^aOrganisms accounting for less than 1% of the sample are listed as other.

^bTwenty-six patients had 2 causative organisms in urine.

^cResistant organisms included extended-spectrum β -lactamase Enterobacteriaceae, methicillin-resistant *Staphylococcus aureus*, and vancomycin-resistant enterococci. No carbapenem-resistant organisms were isolated.

Table 3

Risk factors for bacteremia after catheter-associated bacteriuria (CAB)

Variable	Odds ratio ^a	95% CI	P
Age	0.99	0.97-0.99	.049
Male sex	2.76	1.80-4.21	<.001
Charlson Comorbidity Index	1.04	0.94-1.16	.42
Diabetes mellitus	0.70	0.42-1.18	.18
Malignant neoplasm	1.59	0.88-2.88	.12
Urinary tract disease	0.86	0.54-1.35	.50
Immunosuppressant within 14 days before CAB	1.68	1.06-2.66	.03
Urinary tract procedure	2.70	1.09-6.74	.03
<i>Enterococcus</i> in urine	0.46	0.25-0.83	.01
<i>Klebsiella</i> in urine	1.35	0.78-2.35	.28
Length of stay before CAB	1.02	1.01-1.04	.003
Catheter in place after CAB	2.75	1.65-4.56	<.001

^a A conditional logistic regression model with the 12 variables listed.