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ORIGINAL ARTICLE

Catheter-Associated Bloodstream Infections in General Medical Patients Outside the Intensive Care Unit: A Surveillance Study

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OBJECTIVE. To determine the incidence of central venous catheter (CVC)-associated bloodstream infection (CA-BSI) among patients admitted to general medical wards outside the intensive care unit (ICU).

DESIGN. Prospective cohort study performed over a 13-month period, from April 1, 2002, through April 30, 2003.

SETTING. Four selected general medical wards at Barnes-Jewish Hospital, a 1,250-bed teaching hospital in Saint Louis, Missouri.

PATIENTS. All patients admitted to 4 general medical wards.

RESULTS. A total of 7,337 catheter-days were observed during 33,174 patient-days. The device utilization ratio (defined as the number of catheter-days divided by the number of patient-days) was 0.22 overall and was similar among the 4 wards (0.21, 0.25, 0.19, and 0.24). Forty-two episodes of CA-BSI were identified (rate, 5.7 infections per 1,000 catheter-days). Twenty-four (57%) of the 42 cases of CA-BSI were caused by gram-positive bacteria: 10 isolates (24%) were coagulase-negative staphylococci, 10 (24%) were *Enterococcus* species, and 3 (7%) were *Staphylococcus aureus*. Gram-negative bacteria caused 7 infections (17%). Five CA-BSIs (12%) were caused by *Candida albicans*, and 5 infections (12%) had a polymicrobial etiology. Thirty-five patients (83%) with CA-BSI had nontunneled CVCs in place.

CONCLUSIONS. Non-ICU medical wards in the study hospital had device utilization rates that were considerably lower than those of medical ICUs, but CA-BSI rates were similar to CA-BSI rates in medical ICUs in the United States. Studies of catheter utilization and on CVC insertion and care should be performed on medical wards. CA-BSI prevention strategies that have been used in ICUs should be studied on medical wards.

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Nosocomial infections are a major cause of morbidity and mortality in healthcare systems worldwide and lead to increased healthcare costs. Surveillance for nosocomial infections is an established method to benchmark hospital infection rates, compare infection rates over time,¹ and serve as a quality indicator for infection control.² Accurate and consistent surveillance data are essential to evaluate interventions to reduce the rate of nosocomial infections. The process of surveillance in itself, with appropriate feedback, has been shown to reduce rates of hospital-acquired infections.³

Much of the effort to detect catheter-associated bloodstream infections (CA-BSIs) has been focused on intensive care units (ICUs), where the rate of infection tends to be high because of patients with significant underlying diseases, long hospitalization durations, and extended periods of central venous catheter use. Nontunneled central venous catheters, which are commonly used in the ICU, stand out as a significant risk factors for CA-BSI, and interventions to prevent CA-BSI have primarily involved these catheters.⁴⁻⁶ How-

ever, the majority of nontunneled central venous catheters in use in hospitals at any one time are present in non-ICU patients⁷ and tend to remain in these patients for longer durations, without a clear clinical indication for their use.⁸

Interestingly, the epidemiology of CA-BSI has rarely been investigated outside the ICU setting. A recent study highlighted the influence of central venous catheters and urinary catheters on infections in non-ICU patients and demonstrated several differences between non-ICU and ICU patients.⁹ These data were collected for non-ICU patients in 42 German hospitals and are derived from the German surveillance system for nosocomial infections, using Centers for Disease Control and Prevention (CDC) definitions. Although this study provides the largest source of benchmark data for CA-BSI in non-ICU patients to date, similar benchmark data do not exist for US hospitals in non-ICU wards. Key differences in delivery of care, such as hospital length of stay, exist between healthcare systems in Europe and other countries and those in the United States. Therefore, it is unclear whether

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findings of the study by Vonberg et al.,⁹ which are from a European healthcare system, are applicable in the United States. The purpose of our study was to determine the rate of catheter-related bloodstream infections in non-ICU medical patients by developing a prospective surveillance program for non-ICU CA-BSI in a major teaching hospital.

METHODS

Setting

Barnes-Jewish Hospital, a 1,250-bed teaching hospital, is the largest hospital in Missouri. It employs 7 infection control specialists and their support staff. Surveillance for catheter-associated BSI has been performed in the 6 ICUs. In 2002, interest in CA-BSI on general medical wards increased. It was hypothesized that patients on non-ICU wards at Barnes-Jewish Hospital might be at substantial risk for CA-BSI at rates comparable to CA-BSI rates for ICU patients. To determine whether this was true, 4 general medical wards (A, B, C, and D) were selected for prospective CA-BSI surveillance. Each ward has separate nursing staff. A medical director, interns, residents, and a nurse manager are shared between wards A and B; a different group of staff is shared by wards C and D. Three wards are 26-bed units, and one (ward D) is a 27-bed unit, for a total of 105 patient beds available for study. Each ward received 5-10 new patient admissions daily at the time of the study.

Data Collection and Definitions

A single infection control specialist (C.L.) performed prospective active surveillance for CA-BSI on the 4 selected general medical wards from April 1, 2002, through April 30, 2003. The time required was 2-4 hours per week. All blood cultures with positive results from these units were reviewed after identification through GermWatcher, a locally developed computer-based infection control tool.¹⁰

Data were gathered on catheter start and stop dates, as well as the type of catheter in use, from computerized patient charts. Catheters could be inserted by emergency department physicians, house officers, anesthesiologists, or interventional radiologists. The location of catheter insertion was not recorded. Information on length of hospital stay was taken from the hospital's medical informatics system. Central venous catheter-days were defined as days with 1 or more central

venous catheters in place and were obtained from an electronic report based on the nurses' documentation. The type of central venous catheter was documented (for CA-BSI cases only) and classified as tunneled, nontunneled, peripherally inserted, or implanted, using an established classification model.¹¹ The device utilization ratio was defined as the total number of patient-days with a central venous catheter in situ per total number of patient-days for each unit.

CA-BSIs were defined using CDC criteria.¹² The criteria to determine whether BSIs were catheter associated were developed by O'Grady et al.¹³ A CA-BSI was considered to be related to a specific unit if detected at least 48 hours after admission to or less than 48 hours after discharge from the unit.

Interventions During the Study Period

In the first quarter of 2002, the nursing practice committees of all 4 wards were introduced to the study and the concept of surveillance. Subsequently, monthly rates of BSI were recorded quarterly for each of the 4 wards and discussed during these meetings. To raise awareness for proper infection control measures, a mandatory educational module on the prevention and control of CA-BSI for all nurses on wards A and B was started in December of 2002 (ie, 9 months after surveillance started). This module included an introduction into the concept of surveillance, the causes of and risk factors for nosocomial infection in general and CA-BSI in particular, the epidemiology of CA-BSI, and proper infection control measures to prevent CA-BSI.

Data Analysis

Microsoft Excel 2003 was used for data entry and for calculation of means, rate ratios, and confidence intervals (CIs). For the χ^2 test, the CDC's Web-based 2005 Epi Info program was used (available at: <http://www.cdc.gov/epiinfo/>).

RESULTS

Catheter-Days and Device Utilization Rates

A total of 33,174 patient-days and 7,337 central venous catheter-days were observed during the study period. The monthly mean number of CVC-days per ward was 141 (range, 77-215 CVC-days). The overall device utilization ratio was 0.22 (Table 1).

TABLE 1. Central Venous Catheter (CVC) Utilization and Catheter-Associated Bloodstream Infection (CA-BSI) Rates for 4 General Medicine Wards at a Teaching Hospital in St. Louis, Missouri

Variable	Ward A	Ward B	Ward C	Ward D	Total
No. of CVC-days	1,704	1,989	1,610	2,034	7,337
No. of patient-days	7,978	8,112	8,618	8,466	33,174
Catheter utilization ratio ^a	0.21	0.25	0.19	0.24	0.22
CA-BSI rate ^b	5.3	8.0	4.3	4.9	5.7

^a Defined as the number of CVC-days divided by the number of patient-days.

^b Defined as the number of CA-BSIs per 1,000 catheter-days.

Catheter-Associated Bloodstream Infection Rates

A total of 42 episodes of CA-BSI were identified, corresponding to an overall CA-BSI rate of 5.7 infections per 1,000 catheter-days (95% CI, 3.4-8.0). The mean CA-BSI rate in the 4 units varied between 4.3 and 8.0 infections per 1,000 catheter-days (Table 1). There was no significant difference in rates between the 4 wards (χ^2 for linear trend, 0.42; $P = .52$).

The rate of CA-BSI per 1,000 CVC-days steadily decreased over the study period. The comparison of the first 6 months (27 CA-BSIs during 3,481 catheter-days; 7.8 CA-BSIs per 1,000 catheter-days) with the following 7 months (15 CA-BSIs per 3,856 catheter-days; 3.9 CA-BSIs per 1,000 catheter-days) demonstrated a rate ratio of 0.50 (95% CI, 0.27-0.93).

Thirty-five patients (83%) with CA-BSI had nontunneled catheters, 3 (7%) had totally implanted ports, and 2 (5%) had tunneled catheters. Two patients had more than 1 type of CVC. The types of catheters in patients who did not develop a CA-BSI were not recorded.

Microbiological Characteristics

Twenty-four (57%) of the 42 cases of monomicrobial CA-BSI were caused by gram-positive bacteria: 10 isolates (24%) were coagulase-negative staphylococci, 10 (24%) were *Enterococcus* species, 3 (7%) were *Staphylococcus aureus*, and 1 (2%) was another gram-positive organism. Gram-negative bacteria caused 7 (17%) of the monomicrobial CA-BSIs: 1 isolate (2%) was *Pseudomonas aeruginosa*, 1 (2%) was *Escherichia coli*, 1 (2%) was *Proteus mirabilis*, 1 (2%) was *Enterobacter* species, 1 (2%) was *Klebsiella pneumoniae*, and 2 (5%) were other gram-negative organisms. Furthermore, 5 monomicrobial CA-BSIs (12%) were caused by *Candida albicans*, and 1 (2%) was caused by a *Candida* species other than *C. albicans*. Finally, 5 CA-BSIs (12%) were polymicrobial (Table 2). The potential clonal relatedness of the microorganisms isolated was not determined.

DISCUSSION

There is clearly a need for reference data for CA-BSIs and other device-related infections in non-ICU patients. Although multiple studies of the incidence of CA-BSIs in ICU patients have been done,¹⁴⁻¹⁶ only a few investigators have examined the incidence of these infections in non-ICU inpatient wards.^{9,17-19} In our study, which, to our knowledge, is the largest prospective cohort study performed in the United States to date, we found the incidence of CA-BSIs in non-ICU, general medical patients to be comparable to the rate of CA-BSIs in ICU patients.

In this prospective study of CA-BSIs, we observed a total of 7,337 catheter-days, which to our knowledge exceeds the data reported elsewhere in the literature (4,949 catheter-days).⁹ The device utilization ratio of central venous catheters was 0.22, which is lower than the ratio reported in ICUs (range, 0.51-0.69)^{7,9,20} but comparable to the 0.24 ratio for non-ICU patients in a large survey of central venous access

devices in US teaching hospitals.⁷ However, given that the majority of hospital beds are non-ICU beds, most patients with an intravascular catheter will not be in ICUs.⁷

The device utilization ratio in our study was considerably higher than that reported from the German national surveillance system for general internal medicine wards (ratio, 0.051).⁹ Wischniewski et al.²¹ found a similarly low device utilization ratio (0.061) among non-ICU patients in German hospitals. The reasons for the difference in device utilization in non-ICU wards between the United States and Europe are not clear. This contrasts with the data for central venous catheter use in ICUs, which is much more similar for US and European ICUs.²²

In the study by Vonberg et al.,⁹ the mean duration of hospital stay was 8.2 days, which is longer than that in our population (mean duration, 5.3 days). However, they included community hospitals in their surveillance. Longer length of stay and inclusion of primary and secondary care institutions are both indicators for a lower general level of acuity of illness in the study population, which may account for lower rates of catheter utilization and risk of nosocomial infection.

The overall rate of 5.7 CA-BSIs per 1,000 catheter-days we found in our study is similar to the rate of 4.4 infections per 1,000 catheter-days that Vonberg and colleagues⁹ reported for non-ICU medicine wards. The observed rate of CA-BSI in our study is also very similar to the corresponding rate in

TABLE 2. Pathogens Recovered in Cases of Catheter-Associated Bloodstream Infection at a Teaching Hospital in St. Louis, Missouri

Pathogen	No. (%) of infections ^a (n = 42)
Gram-positive bacteria	
Overall	24 (57)
Coagulase-negative staphylococci	10 (24)
<i>Enterococcus</i> species	
Vancomycin susceptible	7 (17)
Vancomycin resistant	3 (7)
<i>Staphylococcus aureus</i>	
Methicillin resistant	2 (5)
Methicillin susceptible	1 (2)
Other	1 (2)
Gram-negative bacteria	
Overall	7 (17)
<i>Pseudomonas aeruginosa</i>	1 (2)
<i>Escherichia coli</i>	1 (2)
<i>Klebsiella pneumoniae</i>	1 (2)
<i>Proteus mirabilis</i>	1 (2)
<i>Enterobacter</i> species	1 (2)
Other	2 (5)
<i>Candida</i> species	
Overall	6 (14)
<i>C. albicans</i>	5 (12)
Other	1 (2)

^a Five infections (12%) had a polymicrobial etiology.

our medical ICU (5.2 infections per 1,000 CVC-days) over the same 13-month period and is comparable to the mean rate of 5.7 infections per 1,000 CVC-days reported for medical ICUs in the National Nosocomial Infection Surveillance System.²⁰ The reason for this similarity with ICUs is unclear. In a facility with a shortage of ICU beds, Mnatzaganian et al.¹⁹ examined ward patients who qualified as “critically ill,” on the basis of criteria derived from the Society of Critical Care Medicine, and reported lower rates of BSI among critically ill patients housed in regular wards, compared with the rate among ICU patients. Although other factors, such as antibiotic utilization and ward-specific processes, might influence the incidence of CA-BSI, the findings of Mnatzaganian et al.¹⁹ argue against increased severity of illness as the primary risk factor associated with high rates of CA-BSI.

Interestingly, there was a steady decrease in CA-BSI rates during the study period. This trend may be associated with increased staff awareness after receipt of feedback on CA-BSI frequency, which has been shown to reduce infection rates.³ The educational module started on 2 of the wards in December of 2002 (ie, 9 months after the start of surveillance) may have also contributed to the decreased rates, as found in earlier studies involving educational approaches.²³⁻²⁵ The association was not significant, possibly because the sample size was small.

Finally, in our study units, 83% of CA-BSIs occurred in patients with nontunneled central venous catheters. Only a few patients (17%) had catheters meant for long-term use. This reflects the current clinical use of intravascular catheters, in that nontunneled catheters are the most frequently used catheters in the ICU and on regular wards. Climo et al.⁷ found 46% of intravascular catheters to be nontunneled. Details of catheter types were not reported from several other studies of CA-BSIs, which prohibits a comparison of catheter-specific infection rates.

This study has some limitations. We did not determine the patients’ demographic characteristics, severity of illness, or outcomes. Likewise, catheter insertion sites were not documented; therefore, infection rates attributable to a specific insertion site were not computable. Communication of the ongoing surveillance with unit managers and implementation of the educational module may have increased staff adherence to guidelines on proper infection control measures. This may have caused differences between the CA-BSI rates observed in the study wards and rates in non-ICU units without ongoing surveillance and feedback of rates to staff. Finally, this study was performed in a large, academic, tertiary care hospital, and our results may not be generalizable to nonacademic medical centers.

To our knowledge, this is the first study to systematically and prospectively determine the incidence of CA-BSIs among non-ICU patients in the United States. We observed infection rates comparable to those in medical ICUs. Given the differences between service delivery in ICUs and non-ICU wards (which are organizationally more diverse than ICUs), pre-

vention and control of CA-BSIs outside the ICU may require different strategies. Studies of clinicians’ knowledge of and attitude toward central venous catheter insertion and care on regular wards could help establish such strategies. More data to serve as a valid reference for nosocomial infections and their predisposing factors on non-ICU medical wards is warranted. The relatively high incidence of CA-BSI found in this study supports the need for expanding routine CA-BSI surveillance beyond the ICU. However, such surveillance may be limited by infection control resources in most hospitals. Computer-assisted surveillance methods may allow this to occur in the near future.²⁶

The prevention of healthcare-associated infections is an important goal to improve overall quality of care. Recently, the Institute for Healthcare Improvement, for instance, started a major campaign (known as the “5 Million Lives Campaign”) to save lives lost due to healthcare-associated infections and other adverse events in hospitals. The campaign cites the prevention of catheter-related infections as one of its goals but focuses only on ICU patients.²⁷ The results of this study highlight the need for improved surveillance for these infections outside the ICU and for identification or development of prevention measures that can be applied in non-ICU settings.

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Potential conflicts of interest. V.J.F. reports serving as a consultant for Steris and Verimetrix and on the speakers bureau for Pfizer, Merck, and Cubist Pharmaceuticals. D.K.W. reports receiving research support from Sage Products. All other authors report no conflicts of interest relevant to this article.

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