Risk Factors and Clinical Impact of Central Line Infections in the Surgical Intensive Care Unit

Charalambos Charalambous, BSc; Sandra M. Swoboda, RN, MSN; James Dick, PhD; Trish Perl, MD; Pamela A. Lipsett, MD

Objective: To determine the risk factors and clinical impact of central line infections in critically ill surgical patients.

Design: Retrospective study.

Setting: The surgical intensive care unit of a large tertiary care university hospital.

Patients: A total of 232 consecutive central line catheters sent for culture from patients in a surgical intensive care unit during 1996 and 1997. Catheters were sent for microbiologic analysis when the patient was clinically infected and the central line was a possible source.

Interventions: None.

Main Outcome Measures: Risk factors associated and clinical impact of a positive catheter culture.

Results: Of 232 consecutive catheters from 93 patients sent for microbiologic analysis, 114 catheters (49%) had no growth, 40 (17%) were colonized (<15 colonies), and 78 (34%) were considered infected (≥15 colonies). Univariate analysis showed that site (internal jugular vs subclavian, P<.001), catheter use (monitoring > dialysis > fluid > nutrition, P = .006), placement in the operating room vs the intensive care unit (P = .02), and placement of a new catheter (> guide wire, > new site, P = .003) were all significant factors. Surprisingly, neither the number of lumens nor the duration of the catheter in situ were predictors when a catheter was suspected and not proved infected compared with a suspected and proved catheter infection. In the multiple regression model, the placement of the catheter in the internal jugular position was the single most important predictor of a catheter infection (P<.001; odds ratio, 1.83; 95% confidence interval [CI], 1.41-2.37). The presence or absence of a specific clinical sign of infection was not predictive of a proved catheter infection. Eighty-six percent of patients had gram-positive bacteria identified on the culture, while the remaining patients had gram-negative bacteria or Candida identified. Of the catheter infections, 68% were monomicrobial, whereas 32% were polymicrobial. Of the catheters sent for microbiologic analysis, 209 (90%) had concurrent peripheral blood cultures for analysis. Nineteen (32%) with no growth from the catheter, and 14 (23%) of colonized catheters had concurrent bacteremia; all had another identifiable cause of infection. Twenty-seven (45%) of infected catheters had a concurrent bacteremia, and 9 of 27 had a second site positive for the same organism. Death related to the infection occurred in 15 patients, 2 in the first 72 hours and 13 in the following 14 days.

Conclusions: Central line infections remain an important cause of morbidity and mortality. Comprehensive review of hospital practices may show a directed focus for performance improvement practices. At our institution, internal jugular catheters have the highest rate of infection. This may suggest breaks in technique during catheter insertion or during catheter maintenance and care.

Arch Surg. 1998;133:1241-1246
PATIENTS AND METHODS

A retrospective review of 232 consecutive central venous catheters sent for microbiologic analysis for semiquantitative culture from patients in the surgical intensive care unit (SICU) at The Johns Hopkins Hospital, Baltimore, Md, during May 1996 to November 1997 forms the basis of this study. The SICU is a 16-bed unit staffed by an in-house critical care team of residents, fellows, and board-certified intensivists. The type of catheter used in the patients was a polyurethane catheter (Arrow Ak 17702, 15703, or Custom Products, JH04210, SP0981, Reading, Pa). All patients were clinically considered to have an infection with the catheter suspected as a possible source. Catheters removed from patients who were not considered potentially infected or removed for technical problems were not routinely sent for culture.

PROCEDURES FOR INSERTION AND CARE OF CENTRAL LINES

All catheters were inserted by anesthesia or surgical residents under the direct supervision of a fellow or an attending physician. All residents received an orientation before their rotation in the SICU regarding the placement and culture techniques of central venous lines. Residents were required to wear surgical caps and masks, sterile gloves, and large sterile drapes. Surgical gowns were required for the insertion of all Swan-Ganz catheters but were considered optional for other catheters during the period of this review. The insertion site was prepared with 10% povidone-iodine for 2 minutes. The catheter was then inserted percutaneously by the Seldinger technique. For all patients undergoing a guidewire reinsertion, the hub of the first catheter and guidewire were disinfected by means of gauze saturated with povidone-iodine. Sites were dressed with sterile gauze and tape or transparent dressing at the discretion of the bedside nurse. Every 48 hours the dressing was removed, the site inspected and reclensed with povidone-iodine, and a new dressing applied. Clinical findings regarding the insertion site were recorded into the SICU point-of-care computers. New dressings were applied as necessary if they became visibly soiled or insecure. The presence of and ongoing need for a catheter were reviewed daily by the critical care team. Catheters were removed and not routinely sent for culture when the indication for the use of the catheter was no longer present. The minimum number of lumens necessary to meet patient care needs was used. Central venous lines for nutrition were placed and maintained by a nutrition service. These short-term nutrition catheters were always single-lumen catheters placed into the subclavian vein and did not contain any stopcocks.

Catheters considered potentially infected were sent for microbiologic analysis. Irrespective of whether the catheter was being terminally removed or guidewire exchanged, the catheter site was prepared as above. The intradermal portion (3-cm segment) of the catheter was sent for analysis according to the roll-plate technique of Maki et al.7

Medical, microbiologic, and infection control records were reviewed, and data extracted included age, sex, underlying diseases, presence of immunosuppression, operation performed, length of hospitalization, the names of organisms isolated from any concurrent cultures, the use of antimicrobial therapy, susceptibility of isolated organisms, clinical signs and symptoms of infection, and mortality. Specifics of the catheter placement were recorded, such as indication for catheter placement, anatomical site of placement, location of catheter placement (operating room vs SICU), and whether the catheter was a first catheter, a guidewire catheter, or being placed into a new site. Thus, the catheter itself, rather than an individual patient, was

For this study, 232 catheters from 93 SICU patients were examined during 1996 and 1997. These 93 patients represent 10.8% of SICU admissions for this year. Of the 232 catheters inserted in the SICU during this study, 209 (90%) had peripheral blood cultures obtained. The mean number of catheters per patient was 2.5, with a range of 1 to 15. Total number of catheter days in this cohort was 809. There were 114 patients who had no growth from the catheter (group 1), 40 patients with 1 to 14 colonies (group 2), and 78 catheters with 15 or more colonies of organisms isolated from any concurrent cultures (group 3). The median age of the patients was 52 years, which is typical for our SICU patients. Emergency admissions accounted for 77% of patient admissions in this study, a disproportionate number of emergency admissions when compared with overall SICU admissions. However, patient disease category as an indication for admission (gastrointestinal tract emer-
considered the experimental design unit. Blood cultures drawn from an alternative site within 48 hours of the central catheter were compared with organisms isolated from catheters. In all cases, data sheets were independently reviewed by 2 reviewers to classify the origin of infection.

DEFINITIONS

Catheters considered for this study were classified into 3 groups based on the results of the semiquantitative microbiologic culture of the catheter segment. Group 1 catheters (n = 114) did not have any growth, group 2 catheters (n = 40) had less than 15 colonies of growth from the catheter and were considered colonized but not infected, and group 3 catheters (n = 78) had 15 or more colonies of growth and were considered infected. When the blood culture and catheter had the same organism isolated, the antibiotic susceptibilities of the organisms were considered; if identical, the vascular catheter was considered to be the source of the bloodstream pathogen. Probable catheter-associated bacteremia was defined as a blood culture from which organisms grew and no obvious primary site of infection, and a catheter with a negative culture, one with a different microorganism from the blood. For common skin flora (eg, for coagulase-negative Staphylococci, Corynebacterium, Bacillus, Micrococcus, or Propionibacterium species) to be considered a nosocomial bloodstream pathogen, 2 blood cultures positive for the same organism had to be obtained from separate sites within 24 hours or from the same site within 48 hours. A polymicrobial bacteremia was defined as the isolation of 2 or more different organisms during a single bacteremic episode. A body site was considered the source of the bacteremia if the same organism isolated in the blood was also cultured from the body site within 3 days of the bacteremia episode. The medical record was carefully reviewed for changes in antimicrobial therapy surrounding this event. Optimal care was assessed if the catheter was removed within 24 hours of a positive result with 15 or more colonies. If bacteremia was present concurrently, antimicrobial sensitivities were reviewed and antimicrobial therapy around the episode was closely examined. Antimicrobial therapy was considered optimal if empirical therapy was begun at the time of clinical suspicion and the spectrum of coverage was appropriate for the documented susceptibility. If no bacteremia was identified, the catheter was not infected, and no other site of infection was identified, care was considered optimal if antibiotics were stopped within 48 hours of this collective information. The patient’s death was attributed to the vascular catheter–related infection if the death occurred within 72 hours of the infection and no other obvious cause of death (eg, pneumothorax) was present. The catheter-related infection was considered to have contributed to the death if the death occurred between 72 hours and 14 days after the bacteremic event and no other obvious cause of death was present. If the death occurred greater than 14 days after the bacteremic event, the bacteremic event was not considered to have contributed to the death.

STATISTICAL ANALYSIS

Statistical analysis was performed with statistical software (SPSS Version 7.5.1; SPSS Inc, Chicago, Ill). Univariate comparisons between groups were assessed by analysis of variance for continuous variables with the use of an unpaired t test and appropriate nonparametric tests. A 2-sided P < .05 was considered significant. Variables that were clinically important or with a P < .10 in the univariate analysis were then entered into a multiple regression analysis. The sensitivity, specificity, positive and negative predictive values, and likelihood ratio with 95% confidence intervals (CIs) of a catheter categorized by colony count and the presence or absence of bacteremia were examined.
ties or more associated with the catheter and the presence of a bloodstream infection were determined. The sensitivity of a growth of 15 colonies or more associated with the catheter and a positive test result for bloodstream infection was 45%, with a specificity of 70%. The likelihood ratio for a growth of 15 colonies or more associated with the catheter and a negative test result for bacteremia, the negative predictive value was 79% (likelihood ratio, 0.47; 95% CI, 0.26-0.88). Thus, a catheter with a negative culture was not associated with bloodstream infections, while a catheter with a positive culture was associated with bloodstream infection.

In 221 (95%) of 232 catheter episodes, empirical antibiotics were given at the time of a suspected infection. In the 78 patients with documented catheter colony growth of 15 or more colonies, the catheter was removed promptly (<48 hours) after identification of the catheter infection in 70 patients (90%). In the remaining patients, the catheter was removed after a brief trial of antibiotic therapy in 3 (4%) and rewiring and antibiotics in 4 (5%); the exact management could not be determined in 1 (1%). Thus, in patients with a catheter infection, identification of a pathogen from a catheter had a substantial effect on immediate treatment of the patient. Empirical antibiotic management paralleled management of the catheter, identification of a bloodstream pathogen, and/or an alternative site, with the vast majority receiving optimal therapy.

Of the 78 patients with a catheter infection, 34 (44%) died. Death within 72 hours of a catheter infection was seen in 3 patients (9%). In these patients, death was attributed to the catheter infection. In 12 additional pa-
This retrospective study of 232 central venous catheters in clinically infected SICU patients demonstrated that placement of the catheter into the internal jugular vein is positively associated with catheter infection and bloodstream infection. Other commonly considered factors in catheter-associated infection, such as number of lumens, duration of catheter in situ, indication for catheter use, and personnel placing the catheter, did not differentially determine which catheters were infected. These findings are somewhat different from those in other published reports. In previous nonrandomized trials, multilumen catheters were associated with a higher risk of infection than single-lumen catheters. In 2 of 3 randomized trials, multilumen catheters were associated with a higher risk of infection. The difference between the lack of significance of multilumen catheters as a determinant of catheter-associated infection in this series could be explained by the relatively short duration of catheter use, patient disease, or the retrospective nature of this review.

Our finding that the site at which the central venous catheter is inserted and the almost 2-fold increase in infection at a specific site has been previously reported. In 5 of 6 studies that specifically asked the question of anatomical site of insertion, catheters inserted into the internal jugular vein had a significantly higher rate of colonization or infection than central lines inserted into the subclavian vein. In those studies the risk ratio was as high as 2.7, a finding not unlike ours. The reasons for the increased infection rate associated with this site could not be determined from this review but are likely to involve either catheter insertion or, more likely, catheter maintenance and care. However, the finding in the present study that internal jugular catheters have a higher likelihood of infection has focused a multidisciplinary review of policy and procedures in the insertion site selection and maintenance of central venous catheters.

Other known risk factors for central venous catheter infections, such as established infection elsewhere in the body and bacteremia, were certainly seen in this study. However, in this study, catheter infection was not seen more often in the presence of another anatomical site of infection, the most common of which was an intra-abdominal infection. A high rate of bacteremia was seen in all patient groups, but another anatomical site was seen less frequently in patients with a catheter-associated infection.

As is typical of catheter-associated infections and bacteremia, the organisms involved were gram-positive organisms, usually coagulase-negative staphylococci, Staphylococcus aureus, or Enterococcus species. Contrary to the findings of Widmer et al, the finding of a catheter colony count of 15 or more colonies had an important clinical impact on the treatment of our patients. As would be expected by our current practice algorithms, catheters were discontinued almost uniformly once the result of microbiologic testing was known, and most patients were treated empirically with appropriate antibiotics. However, treatment decisions that depend on the semiquantitative technique of catheter analysis have been questioned, because the technique fails to account for endoluminal or hub contamination. Alternative techniques for catheter cultures that allow a catheter to remain in situ, especially when the catheter duration is more longstanding, may be important future developments in the analysis of catheter infections.

Nonetheless, an important finding in this study is that identification of a catheter colony count of less than 15 colonies was not associated with a bloodstream infection, with a negative predictive value of 79% and a likelihood ratio of 0.47. Thus, a catheter with a negative culture is not likely to be associated with bloodstream infection, and this is helpful in making decisions with respect to indwelling catheters in critically ill patients.

Retrospective or prospective analysis of infections associated with central venous catheters is an important quality improvement process. Identification of risk factors specific to a unit will target areas for reeducation and policy enforcement or change. Furthermore, identification of specific areas for improvement may result in decreased morbidity, mortality, and cost of these infections in critically ill patients.


Reprints: Pamela A. Lipsett, MD, Departments of Surgery, Anesthesia, and Critical Care Medicine, 600 N Wolfe St, Blalock 605, Baltimore, MD 21287-4605 (e-mail: plipsett@welchlink.welch.jhu.edu).

REFERENCES

12. Linares J, Sitges-Serra A, Garau J, Perez JL, Martin R. Pathogenesis of catheter...


