Editorial

Prevention of Nosocomial Bloodstream Infections: A National and International Priority

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Nosocomial bloodstream infections (BSIs) are a major cause of morbidity and mortality in the United States and throughout the world. Approximately 8% of all nosocomial infections reported in the United States are primary BSIs; these infections prolong patient hospitalization, are associated with increased mortality, and are costly to the patient and the healthcare system (average US cost per survivor, $40,000).[1-4] Surveillance for nosocomial BSIs is the cornerstone of prevention and control. During 1980 to 1989, 25,269 BSIs were reported from 9,027,541 patients discharged from hospitals participating in the National Nosocomial Infections Surveillance (NNIS) System.[5] During this period, the overall BSI rate increased by 70% at large teaching hospitals and by 279% at small nonteaching hospitals. Four pathogens, coagulase-negative *Staphylococcus* (CNS), *Candida* species, *Staphylococcus aureus*, and *Enterococcus*, accounted for most of the increase. Thus, the major pathogens responsible for the increase in BSI rates are gram-positive organisms rather than gram-negative, which predominated before the 1980s. Furthermore, three of these four pathogens often are treated with vancomycin, but one recently emerged as resistant to vancomycin (*Enterococcus),* and the other two are pathogens for which there is concern about emergence of vancomycin resistance (CNS and *S aureus)*.[6] During January 1990 to April 1995, catheter-associated BSI rates (per 1,000 central catheter days) at NNIS hospital intensive-care units (ICUs) ranged from 4.9 in medical-surgical ICUs to 15.6 in burn ICUs.[7] Patients in neonatal ICUs also are at high risk for BSIs, with umbilical and central catheter-associated BSI rates (per 1,000 catheter days) ranging from 4.9 for infants >2,500 grams to 12.9 for those ≤1,500 grams. Although few data exist on the risk of nosocomial BSIs in developing countries, a point-prevalence study of ICU patients in 17 western European countries found that 20.6% of ICU patients acquired a nosocomial infection and that 12% of these infections were BSIs.[8] This and other studies in the United States show that the risk of BSI is increased significantly (odds ratio, 4.6; 95% confidence interval, 3.1 to 6.8) in patients with central venous catheters (CVCs) and that the increasing use of CVCs has influenced the pathogen prevalence dramatically.[5,8]

Thus, the prevalence of primary BSIs and the pathogens causing these infections are highly correlated with the frequency of use of intravascular catheters. The pathogenesis of intravascular catheter-related infections is complex and multifactorial. The microorganism may be introduced into the bloodstream by (1) intrinsic contamination, ie, contamination of the device or infusate at the time of manufacture; (2) extrinsic contamination, ie, contamination of the device or infusate after manufacture but before insertion or infusion into the patient; (3) contamination of the catheter after insertion, ie, via the hands of healthcare workers (HCWs) during manip-

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ulation of the catheter, catheter site, or fluid pathway; or (4) egress of the patient's own skin flora along the catheter track.

Intrinsic contamination of medical devices or infusates has become nearly unheard of in the United States and throughout the developed world as sterility assurance procedures have been standardized and fully implemented by most manufacturers. Intrinsic contamination of medical devices has not been associated with large outbreaks; conversely, intrinsic contamination of infusates, although very rare, has resulted in large BSI outbreaks. The last reported episode of intrinsic contamination of an infusate in the United States was in 1970 and 1971, when a large outbreak of *Klebsiella, Serratia,* and *Enterobacter* species BSIs was traced to the intrinsic contamination of dextrose-containing intravenous solutions.[9] The most recently reported outbreak in the world was in Greece in 1981 when 63 episodes of BSI and four deaths occurred during a 7-month period at one hospital.[10] Both of these outbreaks were traced to intrinsically contaminated infusate secondary to contamination of the screw top caps of the infusate bottles. Such occurrences have national or international implications and require thorough epidemiologic and laboratory investigation, implementation of corrective action, and follow-up to ensure the efficacy of the interventions. Suspected episodes in the United States should be reported to the Food and Drug Administration (Medwatch, 800-332-1088) and the Centers for Disease Control and Prevention (404-639-6413), or, outside the United States, to the National Ministry of Health or Communicable Disease Control Centers for the country involved.

In contrast to the rarity of intrinsic contamination of medical devices and infusates, extrinsic contamination of these items accounts for most episodes of epidemic and endemic nosocomial BSIs. Such contamination may occur from a wide variety of sources, eg, contamination of the infusate during manipulation but before infusion (admixture of additives, use of single-use bottles as multidose bottles), contamination of intravascular lines or devices set up long before use by the patient, contamination of the medical device or infusate during manipulation by HCWs after the device has been inserted or the infusate is infusing, or contamination of the catheter by the patient's skin flora. In nearly all of these situations, water sources or HCW hands play a critical role in the contaminating event. In this issue of *Infection Control and Hospital Epidemiology,* two reports—one from the United States and one from Mexico—demonstrate the common methods by which HCWs inadvertently have contaminated devices or infusates. The study by Macías-Hernández et al was a cross-sectional culture survey of infusates being administered to febrile or septic patients in the pediatric department of a hospital to evaluate extrinsic contamination; 87 (6.8%) of 1,277 infusates were culture positive.[11] During the 13 months of the study conducted in three areas (neonatal, emergency, and nursery units), in only 1 month were cultures negative from infusates in all three units. Surprisingly, there was no association between receipt of contaminated infusate and clinical sepsis; however, in 8 (62%) of 13 patients, the same species of organism was recovered from the patient's blood and the infusate. The lack of correlation between infusate culture positivity and a patient's clinical status may be explained by the study method, in which the patients chosen for infusate culture already were febrile and appeared septic; the contaminated infusate may have been administered before the febrile episode occurred. Although the microbiologic methods are not described in detail, and thus the culture process cannot be excluded entirely as the cause of some positive cultures, the high rate of contamination appears real. Furthermore, in this outbreak, nurses admixed additives on the ward without the use of a biologic safety cabinet (and presumably sterile technique); this practice has been associated previously with nosocomial BSI outbreaks.[12] These and other data suggest that admixture of infusates should be limited to those settings, preferably the pharmacy, where sterile conditions are available and appropriately trained personnel can adhere strictly to sterile aseptic technique during fluid manipulation.

The study by Rudnick et al demonstrates the high risk of nosocomial BSI associated with intravascular pressure-monitoring equipment.[13] Nosocomial polymicrobial BSIs in open-heart–surgery patients were traced to intravascular devices and pressure transducers that were set up (prefilled and left without line endcaps) the night before the surgical procedure; these devices presumably were contaminated by maintenance personnel spraying water from a hose connected to a malfunctioning disinfectant proportioning device during routine operating room cleaning at the end of each day. Most patients had polymicrobial BSIs with gram-negative organisms. Those patients having the first procedure of the day (and thus exposure to the contaminated devices set up the night before) were at greatest risk of BSI. Unfortunately, cultures of the water from the hose were not obtained until nearly 1 month after the last infection had occurred, when the epidemiologic investigation suggested this method of contamination. Numerous BSI outbreaks have been traced to

pressure transducers.[14-20] In most of these outbreaks, contamination has occurred during HCW manipulation of the transducer dome during recalibration or as a result of improper disinfection or sterilization. Current guidelines recommend the setup of pressure monitoring equipment as near as possible to the time of employment (and thus not set up the night before the procedure); the use of single-use transducers, if possible; or high-level disinfection (or, preferably, sterilization), if reusable transducers are to be used.[16,21] Although Platt et al suggested that transducers be reprocessed using 70% isopropyl alcohol at the bedside of ICU patients,[22] such devices either should not be reused or, if reused, should be sterilized in central supply, where adherence and monitoring of the sterilization process can be done, rather than disinfected at the bedside; this is particularly important in countries in which the infection control infrastructure is in its infancy or nonexistent. As the number of ICU beds increases in the United States and throughout the world, the risk of transducer-associated BSI increases. Recent reports from Europe and India of transducer contamination via the hands of HCWs or by inadequate reprocessing show that this is an international infection control problem that could be alleviated by implementing current guideline recommendations.[18-21]

In both the Macías-Hernández and Rudnick reports, the predominant BSI pathogens were gram-negative. This contrasts with NNIS System data, which show that gram-positive organisms are the predominant and increasing cause of endemic BSI. Furthermore, others have associated resistant strains of gram-negative BSIs in US and European patients with the widespread use of antimicrobials.[23,24] Recent data suggest that gram-negative organisms are reemerging as causative organisms for BSI in selected populations, particularly in patients with hematologic malignancies, in the United States, Italy, and northern Europe and those receiving home infusion therapy in the United States.[25-29] For populations, exposure of the CVCs with external ports to multiple antimicrobials and to tap water through bathing or recreational activities may be contributing to this phenomena. A recent outbreak reported by Pegues et al showed that a hospital in Guatemala with inadequately chlorinated well water had an outbreak of gram-negative BSIs in neonates secondary to infant bathing and insertion of intravascular devices.[30] Thus, the reemergence of gram-negative BSIs in selected populations may be associated with contact of intravascular devices with nonsterile water sources, and these BSIs may be caused by multidrug-resistant organisms. Careful physician review of antimicrobial-use practices and reduction of antimicrobial use in this population, particularly prolonged empiric therapy, would be beneficial. In addition, proper instruction on the care and protection of CVCs should be given to high-risk patients (ie, those at home with long-term CVCs) to reduce improper exposures to nonsterile water sources.

The developed and developing infection control worlds both are struggling with the challenge of conducting active surveillance for nosocomial infections and implementing prevention intervention programs with small or decreasing staffs. In the United States, managed care and healthcare reform are resulting in decreased nursing staffs on our wards and a reduction in the number of personnel in our infection control programs. A recent study suggests that decreased nursing staff in ICUs is associated with an increased BSI risk for patients.[31] In the developing world, many hospitals have either no or very small infection control staffs and few resources to apply to infection control. In both situations, focusing efforts on high-risk patients may be one solution.[32,33] In addition, a study by de Gentile et al in Argentina showed that, in hospitals with small nursing and infection control staffs, recruiting and training patients' family members to conduct many of the routine nursing- care practices free the nursing staff to focus on higher infection-risk practices and result in a decreased risk of nosocomial infection.[34] The recently published draft of the CDC Guidelines for the Prevention of Intravascular Device-Related Infections provides the framework for the prevention of these infections.[21] Many of the recommendations allow for longer use of medical devices, replacement of transducers at 96 hours, catheter-site dressing changes as needed, and change of intravenous tubing at 72 hours; these changes will result in cost savings to our hospitals. The full implementation of similar CDC guidelines has been shown to reduce BSIs and to be cost-beneficial. The challenge of the 1990s will be to implement fully the recommendations, to conduct active surveillance for these infections, to educate the administrators to understand the cost-benefit nature of these recommendations, and to devise new prevention interventions at a time when resources likely will diminish.

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