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Surveillance of Nosocomial Infections by Computer Analysis of Positive Culture Rates

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We describe a surveillance method that identifies excessive rates of positive cultures based on patient location, culture site, and organism identification. During a 6-month period, this surveillance method, coupled with epidemiological investigations, identified 19 small clusters of cross-infections and three small outbreaks of intravenous catheter-related bacteremias. These infections were associated with apparent breakdowns in proper technique. Concurrent, standard surveillance activities identified only three of these problems. These results demonstrate that computer analysis of positive culture rates is a sensitive and time-efficient method for detecting potentially preventable nosocomial infections.

Nosocomial infections are a serious medical problem that gives rise to increased hospital costs and morbidity (10). Many hospital-acquired infections are unavoidable, but some are preventable (16, 17). These infections can be associated with breakdowns in proper technique or contaminated medications and medical devices (20). Hospital infections are primarily detected by comprehensive review of medical charts, nursing care reports, antibiotic use, microbiology reports, and temperature charts (5). These data are generally employed to calculate nosocomial infection rates. However, there is little information available about the benefit of this practice on hospital infection control and the ability of these surveillance activities to detect preventable infections (3, 4). In this report we describe the development and evaluation of a computer-assisted, laboratory-based surveillance system that was employed to identify potentially preventable nosocomial infections and supplement other infection control activities.

MATERIALS AND METHODS

This study was performed at the Tucson Veterans Administration Medical Center during a 6-month period (April 1983 to September 1983). This is a university-affiliated, 325-bed, acute- and chronic-care hospital.

Comprehensive surveillance was performed to identify nosocomial infections and calculate hospital infection rates. Infections were detected by review of all microbiology reports and frequent ward rounds with examination of patient progress notes and temperature charts. In addition, patients were periodically examined to identify infections or potential infection hazards caused by lack of adherence to proper infection control procedures. High-risk areas (e.g., intensive care units) were surveyed more often than low-risk areas. Nosocomial infections were identified by guidelines established by the Centers for Disease Control (2). The following information about each nosocomial infection was recorded and included: primary diagnosis, type and site of infection, ward location, medical team, and microbiology results. This information was employed to calculate monthly nosocomial infection rates and to detect occurrences of related infections that might signify an infection control problem.

Laboratory-based surveillance was performed with the aid of a microcomputer. The programs are written in BASIC (Microsoft Corp.) code. Program functions are chosen, and data are entered by selecting a single number corresponding to a list of appropriate responses. This approach facilitates rapid and accurate data entry. In addition, the most appropriate susceptibility pattern is displayed after the organism and culture site are entered. Any part of the susceptibility results can be quickly edited and filed by moving a cursor on the screen. This method eliminates a major source of data entry errors, and all information from each report can be entered within about 30 s. Data filed in the computer include the following: date of culture, patient identification, patient location, culture site (blood, urine, wound, respiratory, fluid), organism identification, and Kirby-Bauer susceptibility pattern (susceptible, intermediate, or resistant). Another program generates antibiograms for each organism and calculates monthly baseline frequency summaries by bacterial isolate and by culture site. This summary information is sorted by patients' ward locations. In addition, a monthly search is made by site and by organism to identify excessive positive culture rates. Excessive positive culture rates were defined as greater than or equal to twice the ward's average monthly baseline rate, which was derived from the previous 12 months of positive culture results. All excessive positive culture rates, identified by this analysis, were considered to be a potential infection control problem and were epidemiologically investigated by retrospective review of patients' records. Furthermore, these cases were excluded from future baseline calculations.

Patients from the same ward, with positive cultures during the same month, but not identified as part of a cluster, served as case controls. Epidemiological criteria employed for comparisons included the patient's primary diagnosis, use of medical devices, date of culture, room, site of infection, organism identification, and antibiogram. A probable outbreak was identified when common epidemiological patterns were demonstrated within a cluster and similar associations were not present in the control group. Epidemiologically related clusters were further investigated to determine the probable cause for each outbreak. Infections caused by identical organisms in geographically related patients (cross-infections) and by lack of adherence to proper infection control guidelines (breakdown in technique)

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TABLE 1. Results obtained with laboratory-based surveillance system

Mo	Total investigations	Total problems identified	Type of problem		
			Cross-infection	Breakdown in technique	Excessive cultures
April	21	5	3	1	1
May	17	3	1	1	1
June	25	5	4	1	0
July	26	4	4	0	0
August	14	4	4	0	0
September	13	3	3	0	0

were considered potentially preventable nosocomial infections.

RESULTS

Potentially preventable nosocomial infections were found in 22 of 116 (19%) investigations prompted by the computerized surveillance system (Table 1). A positive culture rate greater than or equal to four times the mean rate was associated with significantly greater specificity for identifying problems ($\chi = 4.48$, df = 1, $P < 0.05$; Table 2).

An average of 2.5 patients were involved per problem. Nineteen separate clusters of nosocomial infections due to probable cross-infection were detected (Table 3). These infections included 15 clusters of urinary tract infections and two outbreaks involving wound infections. One patient with *Pseudomonas aeruginosa* empyema was identified as the probable index case for an intravenous catheter site and urinary tract infection. In addition, *Acinetobacter* sp. cross-infection from one patient with sepsis was apparently responsible for a nosocomial urinary tract infection in another patient sharing the same room. Poor intravascular catheter care was the probable cause of three clusters of bacteremia. Finally, two occurrences of a pseudoepidemic were caused by excessive culturing of urine samples from patients with chronic urinary tract infections. Only three of the above problems were identified by concurrent standard surveillance techniques. Furthermore, standard surveillance did not identify any additional infection control problems during the study period.

DISCUSSION

Surveillance is a major part of hospital infection control programs, and infection control practitioners devote more time to this activity than any other task (5). In spite of this effort, many infection control practitioners indicate that routine surveillance does not reduce long-term infection control problems or stop outbreaks at an early stage (5). The most common reason for routine surveillance is to comply with regulatory agency requirements. Although the utility of routine comprehensive surveillance for monitoring hospital infection rates has not been well documented (4), it is recognized that certain groups of patients are at high risk for acquiring nosocomial infections because of their underlying disorders and exposure to multiple procedures (1, 12). Likewise, surveillance activities directed toward specific problems or higher-risk areas are generally more productive (3, 7, 20), and many nosocomial infections are preventable by employing proper management techniques (8, 16, 19). It is therefore important to establish surveillance programs that help identify these problems with the goal of developing policies and procedures to prevent them.

TABLE 2. Positive culture rates compared with likelihood identifying a problem

Positive culture rate[a]	No. of investigations	No. of problems identified (%)
2	45	7 (16)
$>2<4$	50	8 (16)
≥ 4	21	9 (43)

[a] Times increased above mean baseline positive culture rate; by organism or by site.

TABLE 3. Cross-infections

Organism	Site	No. of cross-infections
Klebsiella spp.	Urine	4
Proteus mirabilis	Urine	4
Escherichia coli	Urine	3
Providencia spp.	Urine	2
Staphylococcus aureus	Wound	2
P. aeruginosa	Respiratory tract	1
	Urine	1
Enterococcus	Urine	1
Acinetobacter calcoaceticus	Blood	1

Hospital surveillance programs are primarily designed to monitor infection rates (5, 11). Interpretation of surveillance information generally tends to be subjective and influenced by the judgement of the infection control practitioner. Infection control problems are often identified by the presence of an uncommon bacterial isolate or a substantially increased infection rate. Small outbreaks, especially with commonly isolated organisms or commonly encountered infections, may be masked by other, nonrelated infections. For example, during this study two outbreaks identified by standard surveillance methods involved cross-infection with uncommonly isolated organisms (*Acinetobacter* sp. and *Providencia* sp.) and a bacteremia outbreak from poor intravascular catheter care was detected in three patients.

The clinical laboratory is an important source of culture and antimicrobial susceptibility data that can be utilized to monitor potential problems related to nosocomial infections (9, 11, 21). Review of microbiology reports is the single most common case-finding method routinely employed for nosocomial infection surveillance (5). Wenzel et al. (21) and Gross et al. (9) have reported that chart reviews directed by daily examination of microbiology reports are nearly as efficient as comprehensive surveillance for identifying nosocomial infections. Laboratory-based surveillance allows large amounts of information to be easily collected and frequently reviewed. This facilitates early detection of outbreaks, and epidemiological investigations are directed toward potential problem areas. Computer systems facilitate the collection and processing of this information (13), but there is little information available about the efficacy of this surveillance method for actually detecting or avoiding infection control problems. McGuckin et al. (15) described a manual laboratory-based surveillance method based on an analysis of positive culture rates. Two outbreaks, not immediately recognized by standard surveillance methods, were detected by finding excessive numbers (greater than 1.8

times the mean positive culture rate) of related isolates. Fuchs (6) recommends defining a potential outbreak as greater than 2 standard deviations above the endemic nosocomial infection rate. Our study generally supports this view, although we employed a different data base and analysis technique for defining potential problems.

The results from this study demonstrate that computer analysis of positive culture rates is more sensitive for detecting outbreaks of nosocomial infections that standard surveillance activities. Furthermore, the specificity of this method (likelihood of detecting an infection control problem) increased as higher rates of related positive cultures were identified (Table 2). This finding supports the notion that there is an association between infection control problems and positive culture rates. Furthermore, infection control practitioners will achieve maximum efficiency with this method by investigating clusters associated with the highest positive culture rates.

Most clusters identified by our laboratory-based surveillance technique involved small (two to four) numbers of patients with infections of the urinary tract. Urinary tract infections are recognized as the most common type of hospital-acquired infection, and those caused by cross-infections are preventable (16, 17, 19). All of the urinary tract cross infections occurred on wards with close geographic spacing of patients with indwelling catheters and could theoretically be prevented (17). A recent study of endemic *P. aeruginosa* in an intensive care unit demonstrated that a positive clinical culture result was the only feature differentiating patients involved with cross-infections from those who were only colonized (18). Laboratory-based surveillance may therefore play an important role in the identification and control of nosocomial cross-infections.

Three clusters of nosocomial bacteremia were detected by laboratory-based surveillance. These infections were identified by finding an increased frequency of positive blood culture isolates on certain hospital wards. In all cases, different organisms were involved within each cluster. Investigation of these infections demonstrated an association with poor intravascular care rather than cross-infection. McGowen et al. (14) reported that five of eight nosocomial bacteremias related to intravenous catheters were caused by an apparent breakdown in proper catheter care. This problem may therefore be relatively common and should be preventable (8). An increased frequency of patients with bacteremia may be expected when guidelines for proper intravascular care are not applied, and this study shows that computer analysis of positive blood cultures rates could potentially identify this problem.

The effort required for comprehensive surveillance utilizes a major portion of a hospital's infection control resources and primarily supplies information about nosocomial infection rates. Directed surveillance activities that identify avoidable hospital-acquired infections would substantially improve the practice of infection control. Infections associated with urinary catheters, intravascular devices, and respiratory equipment can often be prevented by appropriate adherence to infection control guidelines. The results of this study suggest that laboratory-based surveillance, utilizing a computer analysis of positive culture rates, is a sensitive and relatively time-efficient method for identifying preventable infections. This directed surveillance technique should complement other infection control activities by identifying potential problems that deserve epidemiological investigation.

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