Nosocomial Bloodstream Infections in Finnish Hospitals during 1999–2000

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Prospective laboratory-based surveillance in 4 Finnish hospitals during 1999–2000 identified 1477 cases of nosocomial bloodstream infection (BSI), with an overall rate of 0.8 BSIs per 1000 patient-days. Of BSI cases, 33% were in patients with a hematological malignancy and 15% were in patients with a solid malignancy; 26% were in patients who had undergone surgery preceding infection. Twenty-six percent of BSIs were related to intensive care, and 61% occurred in patients with a central venous catheter. Sixty-five percent of the 1621 causative organisms were gram positive, 31% were gram negative, and 4% were fungi. The most common pathogens were coagulase-negative staphylococci (31%), Escherichia coli (11%), Staphylococcus aureus (11%), and enterococci (6%). Methicillin resistance was detected in 1% of S. aureus isolates and vancomycin resistance in 1% of enterococci. The 7-day case-fatality ratio was 9% and was highest for infections caused by Candida (21%) and enterococci (18%). The overall rate of nosocomial BSIs was similar to rates in England and the United States, but S. aureus, enterococci, and fungi were less common in our study, and the prevalence of antibiotic resistance was lower.

Nosocomial bloodstream infections (BSIs) are a major cause of morbidity and mortality throughout the world. Approximately 8% of all nosocomial infections reported in the United States are primary BSIs; these prolong patient hospitalization, are associated with increased mortality, and are costly for the health care system [1–5]. The incidence of nosocomial BSIs is increasing, as is the prevalence of antibiotic resistance among pathogens causing these infections [6–11]. Surveillance for nosocomial BSIs is the cornerstone of prevention and control [12–15]. Local surveillance data are the basis for planning interventions in hospitals. The main objective of national hospital infection programs is to promote surveillance by providing a uniform approach to surveillance among participating hospitals and to offer country-specific data on nosocomial infections [16]. Nationally aggregated data also make international comparison possible. Levels of antibiotic resistance vary across Europe [11, 17]. Few systematically collected surveillance data on nosocomial infections and their causative agents from the Nordic countries and countries in which the prevalence of antimicrobial-resistant organisms is relatively low have been published.

The Finnish Hospital Infection Program was started at the end of 1997. Two surveillance modules have now been developed, including hospital-wide surveillance for nosocomial BSIs. In the present article, we report the first results, which consist of the combined data from the 4 hospitals that participated in the program for surveillance for nosocomial BSIs during 1999–2000.
Methods

Hospitals and patients. Four Finnish hospitals volunteered to participate in the surveillance project during 1999–2000: 2 tertiary care hospitals (both with 1600 beds), 1 central hospital (with 600 beds), and 1 district hospital (with 450 beds). Surveillance was active, prospective, and hospital-wide, covering all patients admitted to departments offering acute care. The instructions to the participating hospitals generally advise that blood samples should be obtained for culture if the temperature of a patient is >38°C and/or a patient has other symptoms or signs that are compatible with BSI (e.g., hypothermia or hypotonia). No routine surveillance cultures were performed on samples from asymptomatic patients.

Microbiologic methods. Each participating hospital laboratory detected growth in blood cultures, identified organisms, and performed susceptibility testing according to the modified National Committee for Clinical Laboratory Standards methods standardized by the Finnish Study Group for Antibiotic Resistance.

Case finding and definitions. Local infection-control nurses in each hospital regularly reviewed the laboratory database for positive blood culture results. The Centers for Disease Control and Prevention definition for nosocomial BSI was used, and only laboratory-confirmed BSIs were included in the study [18]. “Primary BSI” referred to bacteremia or fungemia for which there was no documented focal source, including infections that resulted from intravenous or arterial catheter infections. “Secondary BSI” was defined as an infection that developed as a consequence of a documented infection with the same microorganism at another body site. “Polymicrobial BSI” referred to infections in which >1 microorganism was recovered from the blood within a 48-h period. Of the underlying conditions and possible risk factors, type of delivery, whether the patient was a newborn, whether a hematological or solid malignancy was present, and whether the patient had undergone organ transplantation or hemodialysis were recorded, as was the presence or absence of a central venous catheter. All patients who entered the operating room were recorded as having had surgery. Only patients who were hospitalized for at least 24 h in the intensive care unit (ICU) before the occurrence of BSI were considered to have received intensive care. All BSIs that became evident during the ICU stay or within 48 h after discharge from the ICU were considered to be related to intensive care.

Clinical information and microbiological data were recorded by the local infection-control nurses on a standardized case-record form sent monthly to the National Public Health Institute and entered into a common database. The outcome at 7 and 28 days from the date of the first positive blood culture result for a particular patient was obtained from the national population registry by use of unique person identifiers. Patient-days and discharges, by local codes and national specialty codes, were obtained from the information technology department of each hospital.

Statistical analysis. Data were analyzed with Epi Info software (Centers for Disease Control and Prevention). Both antibiotic-resistant and intermediately susceptible organisms were considered to be resistant when resistance percentages were calculated. Univariate analysis of categorical variables was done with the chi-square test, using Yates’s correction, or Fisher’s exact test, as appropriate. Continuous variables were analyzed by Student’s t test or by the Mann-Whitney U test, depending on the sample distribution.

Feedback. Feedback was given through the project Web site, which was only accessible by use of a password given to authorized persons from the participating hospitals. Each hospital had access to its own data, and all hospitals had access to the aggregated data. Feedback included several report tables

Table 1. Nosocomial bloodstream infection (BSI) rates and proportion of BSIs related to intensive care, by specialty, in 4 Finnish hospitals during 1999–2000.

<table>
<thead>
<tr>
<th>Specialty</th>
<th>No. of BSIs</th>
<th>No. (%) of intensive care-related BSIs</th>
<th>BSIs/1000 patient-days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal medicine</td>
<td>664</td>
<td>69 (10)</td>
<td>1.6</td>
</tr>
<tr>
<td>Pediatrics</td>
<td>275</td>
<td>113 (41)</td>
<td>1.3</td>
</tr>
<tr>
<td>Oncology</td>
<td>85</td>
<td>0</td>
<td>1.2</td>
</tr>
<tr>
<td>General surgery</td>
<td>321</td>
<td>147 (46)</td>
<td>0.6</td>
</tr>
<tr>
<td>Neurology</td>
<td>51</td>
<td>27 (53)</td>
<td>0.4</td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>19</td>
<td>16 (84)</td>
<td>0.3</td>
</tr>
<tr>
<td>Pulmonology</td>
<td>31</td>
<td>7 (23)</td>
<td>0.3</td>
</tr>
<tr>
<td>Gynecology and obstetrics</td>
<td>29</td>
<td>1 (3)</td>
<td>0.1</td>
</tr>
<tr>
<td>Oral surgery</td>
<td>1</td>
<td>1 (100)</td>
<td>0.1</td>
</tr>
<tr>
<td>Dermatology</td>
<td>1</td>
<td>1 (100)</td>
<td>0.03</td>
</tr>
<tr>
<td>Total</td>
<td>1477</td>
<td>382 (26)</td>
<td>0.8</td>
</tr>
</tbody>
</table>
RESULTS

A total of 1477 BSIs confirmed by positive results of blood culture were identified in 1265 patients. The overall infection rate was 0.8 infections per 1000 patient-days (range, 0.4–0.9) and 2.7 infections per 1000 discharges (range, 1.3–3.1). During the same period of time, 92,299 blood samples were obtained for culture (range, 42–54 cultures per 1000 patient-days), and 16 BSIs were confirmed per 1000 blood cultures (range, 8–18). The rate of BSIs was highest among patients given care in internal medicine, pediatrics, oncology, and general surgery (table 1). The proportion of infections related to intensive care was highest among surgical, neurological, and pediatric patients. Most (77%) of the infections became evident during the hospital treatment period in which they were acquired; 23% were related to a preceding treatment period. Of the infections, 1229 (83%) were primary BSIs and 248 (17%) were secondary BSIs (84 [34%] of 248 BSIs).

The mean age of the patients with BSI was 46 years (range, 1–100 years), and 865 (59%) were male. One-third of the infections occurred in patients who had a hematological malignancy (table 2). One-quarter of the infections occurred in surgical patients (26%) and in intensive care patients (26%). Information about the presence or absence of a central venous catheter within a 48-h period before the onset of the infection was available for 1152 infections (78%), and a catheter was present for 703 (61%) of those 1152 infections.

A total of 1621 isolates were recovered from samples obtained during 1477 BSI episodes. Polymicrobial infections accounted for 9% (126) of the episodes. Sixty-five percent (1054) of causative organisms were gram positive, 31% (505) were gram negative, and 4% (62) were fungi. Of the bacteria, 55 (4%) were anaerobes. The most common pathogens were coagulase-negative staphylococci (CoNS), Escherichia coli, Staphylococcus aureus, and enterococci (table 3). Most CoNS (77%) were Staphylococcus epidermidis. Of enterococci, 59 (58%) were Enterococcus faecalis, and 40 (40%) were Enterococcus faecium. After E. coli, the most common gram-negative rods were Klebsiella and Pseudomonas species. Of the 62 Candida isolates, 23 were species other than Candida albicans (8 isolates were Candida parapsilosis, 4 were Candida glabrata, 2 were Candida tropicalis, and 9 were nonspéciéd Candida strains). The estimate for the proportion of non-albicn Candída species varies from 23% to 37%, depending on whether the 9 nonspéciéd Candida isolates are included.

CoNS were the most common pathogens in all patient groups, except in obstetric patients, among whom S. aureus was equally common. Group B streptococci were common among newborns (17% of the microorganisms causing BSI among newborns vs. 1% among other patients; P < .01), and viridans streptococci were common among patients with hematological malignancy (11% among patients with hematological malignancy vs. 3% among other patients; P < .01). Candida species were more likely to cause BSIs in newborns (10% among newborns vs. 3% among other patients; P < .01) and patients in the ICU (10% among patients in the ICU vs. 2% among other patients; P < .01). Among patients with hematological malignancies, S. aureus (5% of isolates) and Candida species (2% of isolates) were rare.

Resistance to methicillin was detected in 1% of S. aureus and 76% of CoNS isolates (table 4). Among enterococci, the proportion of vancomycin-resistant isolates was 1%. Among viridans streptococci, the proportion of penicillin-resistant isolates was 24%. Approximately one-third of Pseudomonas aeruginosa
Table 4. Rates of antibiotic resistance among the most common gram-positive bacteria and gram-negative rods causing bloodstream infections in 4 Finnish hospitals during 1999–2000.

<table>
<thead>
<tr>
<th>Antibiotic</th>
<th>CoNS</th>
<th>Staphylococcus aureus</th>
<th>Enterococci</th>
<th>Viridans streptococci</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ampicillin</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Penicillin</td>
<td>—</td>
<td>—</td>
<td>24 (19/79)</td>
<td>—</td>
</tr>
<tr>
<td>Erythromycin</td>
<td>63 (312/494)</td>
<td>10 (17/170)</td>
<td>—</td>
<td>31 (25/80)</td>
</tr>
<tr>
<td>Imipenem/meropenem</td>
<td>—</td>
<td>—</td>
<td>42 (39/93)</td>
<td>0 (0/50)</td>
</tr>
<tr>
<td>Clindamycin</td>
<td>53 (261/492)</td>
<td>4 (7/170)</td>
<td>—</td>
<td>6 (5/77)</td>
</tr>
<tr>
<td>Oxacillin/methicillin</td>
<td>76 (363/480)</td>
<td>1 (2/163)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Ciprofloxacin</td>
<td>32 (19/59)</td>
<td>17 (6/25)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Gentamicin</td>
<td>—</td>
<td>—</td>
<td>7 (1/15)</td>
<td>—</td>
</tr>
<tr>
<td>Tobramycin</td>
<td>63 (202/320)</td>
<td>3 (3/97)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Vancomycin</td>
<td>0 (0/487)</td>
<td>0 (0/167)</td>
<td>1 (1/97)</td>
<td>0 (0/82)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Antibiotic</th>
<th>Escherichia coli</th>
<th>Klebsiella species</th>
<th>Pseudomonas aeruginosa</th>
<th>Enterobacter species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ampicillin</td>
<td>44 (77/177)</td>
<td>99 (80/81)</td>
<td>—</td>
<td>100 (53/53)</td>
</tr>
<tr>
<td>Piperacillin/tazobactam</td>
<td>1 (2/169)</td>
<td>3 (2/76)</td>
<td>30 (24/79)</td>
<td>25 (13/52)</td>
</tr>
<tr>
<td>Imipenem/meropenem</td>
<td>0 (0/167)</td>
<td>0 (0/77)</td>
<td>12 (9/78)</td>
<td>2 (1/48)</td>
</tr>
<tr>
<td>Cefotaxime</td>
<td>2 (4/176)</td>
<td>1 (1/75)</td>
<td>—</td>
<td>39 (20/51)</td>
</tr>
<tr>
<td>Ceftazidime</td>
<td>2 (3/175)</td>
<td>0 (0/78)</td>
<td>11 (9/79)</td>
<td>31 (16/51)</td>
</tr>
<tr>
<td>Cefuroxime</td>
<td>6 (10/176)</td>
<td>11 (9/80)</td>
<td>—</td>
<td>61 (31/51)</td>
</tr>
<tr>
<td>Ciprofloxacin</td>
<td>5 (6/122)</td>
<td>6 (3/50)</td>
<td>38 (30/80)</td>
<td>0 (0/57)</td>
</tr>
<tr>
<td>Tobramycin</td>
<td>1 (2/160)</td>
<td>0 (0/67)</td>
<td>30 (24/80)</td>
<td>2 (1/42)</td>
</tr>
<tr>
<td>Amikacin</td>
<td>—</td>
<td>—</td>
<td>4 (3/67)</td>
<td>—</td>
</tr>
</tbody>
</table>

NOTE. CoNS, coagulase-negative staphylococci.

isolates were resistant to piperacillin/tazobactam, one-third to ciprofloxacin, one-third to tobramycin, 12% to imipenem, and 11% to ceftazidime. When the resistance to ceftazidime was used as a marker for the potential presence of extended-spectrum β-lactamases, 2% of E. coli and 0% of Klebsiella isolates were potential carriers of these enzymes.

Information about outcome was available for 97% of patients. Among those patients, 123 (9%) died within 1 week after the onset of BSI, and 232 (16%) died within 1 month. The case-fatality ratios were highest for infections caused by Candida and those caused by enterococci (table 3). The patients who died were significantly older (61 vs. 45 years; P < .01) and were more likely to have had a solid malignancy (32% vs. 13%; P < .01) or to have been admitted to the ICU (40% vs. 24%; P < .01).

**DISCUSSION**

Our surveillance focused on a single type of nosocomial infection with serious consequences: BSI [1–5]. In addition to being associated with significant morbidity and mortality, nosocomial BSIs are an important marker of antibiotic resistance among organisms that cause nosocomial infections.

Hospital-wide surveillance data on BSIs have been collected in England, where 61 hospitals participated in a surveillance program during 1997–1999 [19]. The overall BSI rate was similar to that in Finland; the mean rate in England was 0.6 infections per 1000 patient-days, compared with 0.4–0.9 infections per 1000 days, the rate observed in our study. In earlier reports from the United States, the rates were also similar; in 1989, the primary BSI rate varied in nonteaching hospitals from 1.3 to 2.5 infections per 1000 discharges and in teaching hospitals from 3.8 to 6.5 infections per 1000 discharges, compared with 1.3–3.1 infections per 1000 discharges in our study [7].

In our study, BSIs caused by methicillin-resistant S. aureus (MRSA) and vancomycin-resistant enterococci (VRE) constituted only 1% of the S. aureus and enterococcal isolates, even though 2 of the largest tertiary care hospitals in Finland were involved. In England, almost one-half of S. aureus isolates from...
BSIs were resistant to methicillin, and 10% of enterococcal isolates were resistant to vancomycin [19]. Furthermore, in the United States, the proportion of MRSA among S. aureus causing BSI was 29%, and the proportion of VRE among enterococci was 18% [20]. However, the prevalence of antibiotic resistance among CoNS, viridans streptococci, and *Pseudomonas* species in Finland was similar to or higher than that reported in the United States and England [19, 20]. The methods used for susceptibility testing by the microbiology laboratories involved in our study were standardized, as part of a separate project carried out by the Finnish Study Group for Antibiotic Resistance, before our surveillance began.

More than one-half of the causative microorganisms in our study were gram positive; this finding is similar to published results from the surveillance network of 49 US hospitals (Surveillance and Control of Pathogens of Epidemiologic Importance; SCOPE) during 1995–1998 [20]. *S. aureus*, enterococci, and *Candida* species were less common in our study than in the United States, but the proportions of CoNS and polymicrobial infections were similar [20]. Our maximum estimate for the proportion of nosocomial BSIs caused by *Candida* species other than *C. albicans* was smaller than that for the US hospitals (37% vs. 47%, respectively) [20].

Unique person identifiers allowed us to retrieve comprehensive data on the outcomes of infections from the national population registry. Almost one-tenth of patients with nosocomial BSIs died within 1 week of the first positive blood culture result, and 16% died within 1 month. The case-fatality ratios were highest for infections caused by *Candida* species (42%) and enterococci (31%). In the US SCOPE network, the 1-month case-fatality ratio varied by microorganism, from 21% to 40%, and, in a teaching hospital in Iowa during the 1980s and 1990s, from 17% to 35% [20, 21].

Comparison of site-specific infection rates between different hospitals is not recommended [16]. However, our feedback on the surveillance results to participating hospitals raised great interest, because no uniformly collected data on overall rates, rates by specialty, distribution of causative agents, and antibiotic-resistance patterns among causative agents for different patient groups had previously been available. The participating hospitals have had an opportunity to analyze their own data by time, place, and patient group, as well as to compare these data with the results of the aggregated data. This enables the hospitals to identify problem areas in which interventions and/or intensified surveillance are needed.

The national hospital infection programs in many European countries and in the United States include in their surveillance, in addition to surgical-site infections, only infections in ICUs [16]. Resources can be saved by focusing the surveillance on high-risk units and procedures. Focusing also allows more exhaustive collection of data on device use for improved risk adjustment and more-reliable estimations of the effect of control interventions. On the basis of our results, the surveillance of blood culture–confirmed nosocomial BSIs and control measures should be intensified, at least in ICUs and in oncology and hematology specialties. Whether surveillance in ICUs also should cover infections that manifest in wards after patients have been discharged from ICUs requires further analysis.

In conclusion, the overall rate of nosocomial BSIs in Finnish hospitals was similar to the rates reported for other European countries and for the United States. However, the proportions of BSIs caused by *S. aureus*, enterococci, and yeasts were smaller, and the prevalence of antibiotic susceptibility among *S. aureus* and enterococci was significantly higher.

**HOSPITAL INFECTION SURVEILLANCE TEAM MEMBERS**


**References**


