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Bloodstream infections in a medical–surgical intensive care unit: incidence, aetiology, antimicrobial resistance patterns of Gram-positive and Gram-negative bacteria

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Abstract

In the present study, the incidence and antimicrobial resistance patterns of the microorganisms that caused bloodstream infections (BSIs) in a medical–surgical intensive care unit during the years 2005–2007 were determined. The mean BSI incidence density was 6.56 per 1000 patient-days. The incidence density increased linearly during the study period (from 3.57 to 9.60 per 1000 patient-days). *Staphylococcus aureus* was most frequently isolated (47.3%), followed by *Enterococcus* spp. (10.8%) and *Candida* spp. (10.1%). There was a high rate of resistance to several of the prescribed antimicrobials among the bacteria isolated from patients with BSIs.

Keywords: Bloodstream infection, incidence, aetiology, antimicrobial resistance, intensive care unit
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Introduction

Bloodstream infections (BSIs) occur more frequently in patients hospitalized in intensive care units (ICUs) than in other units. It has been shown that these patients stay in clinics longer than others. BSIs also cause an increase in hospital mortality rates and excess cost. Early initiation of appropriate antimicrobial treatment is critical in decreasing morbidity and mortality among patients with BSI [1–3].

The frequency, epidemiology and microbiological profile of nosocomial BSIs varies among institutions and also among ICUs within hospitals. Therefore it is important to know the pathogens causing BSIs and their antimicrobial resistance patterns to guide appropriate antimicrobial treatment. Based on local surveillance data, each centre should make its own therapatic choices [1,4]. The objective of this study was to determine the incidence and the aetiology of BSIs, and the antimicrobial resistance patterns of the BSI-causing microorganisms, in the medical–surgical ICU of Haydarpasa Numune Hospital, Istanbul, Turkey.

Patients and Methods

Setting

This observational study was performed in the medical–surgical ICU of a teaching hospital with 750 beds in Istanbul, during the years 2005–2007. The ICU, which had 12 beds in 2005, grew to have 21 beds and moved to a new location within the hospital in 2006. The ICU had a patient-to-nurse ratio of 3 : 1 during the daytime and 2 : 1 at night in 2005, but in 2006–2007 this ratio was 4 : 1 during daytime and 3 : 1 at night.

Data collection

The patients hospitalized longer than 48 h in the ICU were included in this study. The diagnosis of BSI was based on the criteria of the Center for Disease Control (CDC) [5]. Isolates were identified using standard methods [6]. Antimicrobial resistance patterns of isolated microorganisms were determined using the disc diffusion agar method according to

the recommendations of the Clinical Laboratory Standards Institute (CLSI) [7]. The statistical analysis of the data was done using the chi-square test or Fisher's exact test when expected values were small.

Definitions

BSI was defined as the isolation of a pathogenic microorganism from at least one blood culture specimen. Organisms of the skin flora commonly associated with contamination were required to be isolated from two separate blood culture specimens. A poly-microbial BSI was defined as the isolation of more than one organism from blood culture specimens. A BSI was classified as primary in the absence of an identified source of infection or if it was catheter related. A BSI was classified as secondary in the presence of an identified source infected with the same microorganism at another body site. Incidence density of BSIs was calculated per 1000 patient-days. The incidence density of catheter-associated BSIs was calculated per 1000 catheter-days.

Results

In total, 2627 patients were admitted to the medical–surgical ICU during the 3-year study period. The main admission diagnoses were respiratory (20.36%) and neurological diseases (19.03%) between the years 2005–2007; 121 (4.60%) episodes of BSI among 113 patients were identified. The majority of the episodes (116; 95.9%) were monomicrobial, the rest (5, 4.1%) were polymicrobial; 83 (68.6%) episodes were classified as primary BSI, 48 (57.8%) of which were vascular catheter associated. Thirty-eight (31.4%) episodes were classified as secondary BSI of which 30 (24.8%) were secondary to a lower respiratory tract infection, five (4.1%) secondary to a urinary tract infection and three (2.5%) secondary to infection of other sites. The incidence densities of primary and secondary BSI were 4.50 and 2.06 per 1000 patient-days, respectively. The incidence density of catheter-associated BSI was 2.92 per 1000 catheter-days. The mean incidence density of BSI was 6.56 per 1000 patient-days (range, 3.57–9.60 episodes). The incidence density of BSI increased during the study period from 3.57 episodes in 2005 to 5.61 in 2006 and to 9.6 per 1000 patient-care days in 2007; these results were statistically highly significant ($p < 0.0001$) (Table 1).

Among the BSI episodes, 83 (64.3%) were caused by Gram-positive organisms, 25.6% by Gram-negative organisms and 10.1% by fungi. The most fequently isolated microorganisms of BSIs were *Staphylococcus aureus* (47.3%), enterococci (10.8%) and *Candida* spp. (10.1%). *Candida albicans* (44.5%) was the most frequently isolated species, followed by *C. tropicalis* (33.3%), *C. glabrata* (11.1%) and *C. parapsilosis* (11.1%). The proportion of enterococcal species isolated from BSIs increased from 5.5% in 2005 to 10.8% in 2007 ($p = 0.4522$). The proportion of *Candida* spp. isolated from BSI increased from 5.5% in 2005 to 10.1% in 2007 ($p = 0.6799$). However, there was a decrease in the proportion of Gram-negative bacteria isolated from BSI, from 38.8% in 2005 to 23.6% in 2007 ($p = 0.2870$). *Acinetobacter* spp. were the most frequently isolated Gram-negative bacteria. The data are summarized in Table 2.

In the present study, all isolates of *S. aureus* and coagulase-negative staphylococci (CoNS) were resistant to methicillin. All isolates were susceptible to vancomycin, teicoplanin and linezolid. The rate of vancomycin resistance among *Enterococcus* spp. was 50%. All seven of these resistant isolates were *Enterococcus faecium*. Of 14 *Enterococcus* spp., only four (28%) isolates were susceptible to ampicillin. The effective antibiotics against the Gram-negative bacteria were amikacin, imipenem and cefoperazone-sulbactam. Among the Gram-negative bacteria, the rates of resistance to various antibiotics commonly used in the ICU were as follows: amikacin 18%, imipenem 21%, cefoperazone-sulbactam 24%, ciprofloxacin 70%, ceftazidime 79%. Cefoperazon-sulbactam showed high activity against *Acinetobacter* spp., whereas amikacin showed high activity against *Pseudomonas aeruginosa*. The rates of resistance to imipenem were 37% and 38% for *Acinetobacter* spp. and *P. aeruginosa*, respectively. These results are shown in Table 3 in detail.

TABLE 1. Accumulated incidence of bloodstream infections

	2005	2006	2007	Total
Number of BSI cases	18	36	67	121
Rate per 100 patients	2.40	3.92	6.90	4.60
Patients days	5036	6407	6979	18 422
Rate per 1000 patient-days	3.57	5.61	9.60	6.56

BSI, bloodstream infections.

TABLE 2. The distrubition of pathogens isolated from patients with BSIs

	2005		2006		2007		Total	
Microorganism	***n***	**%**	***n***	**%**	***n***	**%**	***n***	**%**
Staphylococcus aureus	8	44.7	21	53.8	32	44.4	61	47.3
Coagulase-negative staphylococci	1	5.5	3	7.7	4	5.5	8	6.2
Enterococcus spp.	1	5.5	3	7.7	10	14.0	14	10.8
Pseudomonas aeruginosa	3	16.8	1	2.6	4	5.5	8	6.2
Acinetobacter spp.	1	5.5	5	12.8	5	7.0	11	8.5
Escherichia coli	1	5.5	0	0.0	2	2.8	3	2.3
Klebsiella pneumoniae	1	5.5	2	5.1	2	2.8	5	3.9
Enterobacter spp.	1	5.5	1	2.6	4	5.5	6	4.7
Candida spp.	1	5.5	3	7.7	9	12.5	13	10.1
Total	18	100.0	39	100.0	72	100.0	129	100.0

TABLE 3. Antibiotic resistance rates among 33 Gram-negative pathogens isolated from BSIs

	Antibiotic resistance rates									
	Ceftazidime		Imipenem		Ciprofloxacin		Cefoperazone-sulbactam		Amikacin	
Pathogen	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Acinetobacter spp. (*n* = 11)	10	91	4	37	8	73	0	0	5	45
Pseudomonas aeruginosa (*n* = 8)	5	63	3	38	6	75	4	50	0	0
Enterobactericeae (*n* = 14)	11	79	0	0	9	64	4	29	1	7
Total	26	79	7	21	23	70	8	24	6	18

Discussion

Nosocomial BSIs are associated with a high morbidity and mortality. Patients hospitalized in ICUs are at particulary high risk of nosocomial BSIs because of their debilitated condition as a result of underlying disease and frequent invasive diagnostic and therapeutic procedures [8,9]. Incidences of nosocomial BSIs in ICU patients reported in the literature are less than 5% [3,9]. The incidence density of BSIs in ICUs has been reported to vary from 4.2 to 6.0 per 1000 patient-days [3,10–12].

In this study, the incidence of BSIs was 4.60%. The mean incidence density of nosocomial BSIs was 6.56. In 2007, there was a significant increase in the incidence of BSIs. This study had not assessed the characteristics and risk factors of the patients with BSI. The main diagnoses of the patients upon admission to the ICU were similiar during the 3-year study period. We know that an insufficient number of nurses is an important problem in the ICU of Haydarpasa Numune Hospital which may explain why effective strategies to prevent and control hospital infections are needed.

Organisms causing nosocomial BSIs vary depending upon the location of patients within the institution [1]. In many studies, the dominance of Gram-positive pathogens has been documented. CoNS, *S. aureus* and enterococci were the three most common causes of nosocomial BSIs in many institutions [1,4,10,13,14]. There has been a decrease in relative importance of infections as a result of Gram-negative bacteria over the past three decades [3,15]. *Candida albicans* is still considered the most frequently isolated fungal agent of BSI, but trends towards increasing numbers of non-albicans *Candida* among bloodstream pathogens have been reported [16].

In this study, the majority of ICU-acquired BSIs were as a result of Gram-positive organisms. The most frequently isolated microorganisms causing BSIs were *S. aureus* (47.3%), enterococci (10.8%) and *Candida* spp. (10.1%).

Most of the fungi were *C. albicans*. There was an increase in the proportion of enterococci and *Candida* species among isolates from BSIs. This increase may be explained by extensive use of antibiotics and indwelling devices in this unit.

Increasing antimicrobial resistance rates among microorganisms isolated from BSIs are a significant problem worldwide. Methicillin-resistant *S. aureus* (MRSA), vancomycin-resistant enterococci (VRE), extended-spectrum beta-lactamase-producing *Klebsiella* spp., carbapenem-resistant enterobactericeae, *P. aeruginosa* and *Acinetobacter* spp. were seen more frequently in ICU patients than in non-ICU patients in many countries [1,8,17–23]. Antimicrobial resistance rates among pathogens isolated in ICUs in Turkey were high [24–26]. In the present study, all staphylococcal isolates were methicillin resistant and belonged to an endemic strain (data not shown).

The rate of VRE was 50%. Vancomycin was used frequently in this unit. There was an increase in the frequency of VRE in 2007. Amikacin, imipenem and cefoperazone-sulbactam were the most active compounds against Gram-negative bacteria.

In conclusion, this study demonstrates a high rate of antimicrobial resistance to several prescribed antibiotics among the microorganisms isolated from patients with BSIs. During the 3-year period, there was a tendency towards an increase in frequency of BSIs and BSIs as a result of enterococci and *Candida* spp. were more common in 2007. The insufficient antibiotic-prescribing practices, especially the unnecessary use of broad-spectrum antibiotics together with the insufficient hospital infection prevention programme, are considered to be the cause of both a high antimicrobial resistance rate and an increased incidence of BSI.

Transparency Declaration

The authors declare that they have no conflicting or dual interest.

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