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Original Article

Predominance of Gram-negative bacilli and increasing antimicrobial resistance in nosocomial bloodstream infections at a university hospital in southern Taiwan, 1996-2003

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Background and Purpose: While nosocomial infections cause substantial morbidity and mortality, the availability of timely and accurate epidemiological information on nosocomial pathogens is essential to the appropriate selection of empirical therapy. This study analyzed nosocomial bloodstream infections (NBSIs) surveillance data to determine trends in the distribution of pathogens and antimicrobial susceptibilities of these pathogens.

Methods: During the period from 1996 to 2003 at National Cheng Kung University Hospital, patients with NBSIs were enrolled in the study, and the ranking of pathogens and status of antimicrobial resistance were determined.

Results: From 1996 to 2003, there were 4038 episodes of NBSIs. The overall incidence was 1.79 episodes per 1000 inpatient-days. Aerobic Gram-negative bacilli, Gram-positive cocci, fungi, and anaerobes were responsible for 51%, 37%, 10%, and 1.6% of NBSIs, respectively. The 5 leading pathogens were coagulase-negative staphylococci (16% of NBSIs), *Staphylococcus aureus* (13%), *Candida* spp. (10%), *Acinetobacter baumannii* (8%), and *Escherichia coli* (8%). Oxacillin resistance was found in 90% of coagulase-negative staphylococci and 75% of *S. aureus* isolates. In contrast to *Enterococcus faecalis*, in which only 1% of isolates were resistant to ampicillin, 78% of *Enterococcus faecium* isolates were resistant to ampicillin. The emerging antimicrobial-resistant Gram-negative pathogens included multidrug-resistant *A. baumannii*, cephalosporin- or fluoroquinolone-resistant *E. coli,* and extended-spectrum beta-lactamase producing *Klebsiella pneumoniae* and *E. coli.* Despite the annual increase in the use of fluconazole, *Candida albicans* (54%) remained the most common causative pathogen of nosocomial candidemia.

Conclusions: In summary, Gram-negative bacilli predominated among pathogens causing NBSIs and an upsurge in the threat of antimicrobial resistance in our hospital occurred during the 8-year period. Surveillance of the characteristics of NBSIs and antimicrobial resistance patterns, together with appropriate antibiotic and infection control measures, should be reinforced.

Key words: Bacteremia, cross infection, drug resistance, Gram-negative bacteria, microbial sensitivity tests

Introduction

Nosocomial infections are increasing in prevalence due to a number of factors, including aging populations, increasing numbers of immunocompromised patients, as well as increasing use of invasive interventions. Previous studies showed that nosocomial bloodstream infections (NBSIs) were associated with increased morbidity, mortality, length of hospital stay, and costs [1-3]. Among the causative pathogens, coagulase-negative staphylococci, followed by *Staphylococcus aureus*, *Enterococcus* spp., *Candida* spp., and *Enterobacter* spp. were the most frequently reported by the National Nosocomial Infections Surveillance System in the United States from 1990 to 1999 [4]. Data from this surveillance system also demonstrated

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increasing antimicrobial resistance during the past decade, including vancomycin-resistant enterococci (VRE), methicillin-resistant *S. aureus*, third-generation cephalosporin-resistant *Escherichia coli*, and quinolone- or imipenem-resistant *Pseudomonas aeruginosa*.

In the last decade, studies in Taiwan have found an increasing prevalence of antimicrobial-resistant bacteria, such as methicillin-resistant *S. aureus*, pan-drug-resistant *Acinetobacter baumannii*, and extended-spectrum beta (β)-lactamase (ESBL)- producing *E. coli* and *Klebsiella pneumoniae* [5-10]. Nosocomial candidemia caused by non-albicans *Candida* spp. was also increasingly noted [11,12]. However, the distribution and antimicrobial susceptibility of pathogens causing nosocomial infections varied considerably in different regions, over time and among hospitals. The availability of timely and accurate epidemiological information on nosocomial pathogens is essential to the appropriate selection of empirical therapy. This study analyzed nosocomial infection surveillance data from National Cheng Kung University Hospital from 1996 to 2003 in order to determine trends in the distribution of pathogens causing NBSIs, antimicrobial susceptibilities of these pathogens, and temporal correlation of antimicrobial resistance with antibiotic usage.

Methods

National Cheng Kung University Hospital, a university-affiliated medical center in southern Taiwan, has approximately 900 beds, including 3 medical intensive care units (ICUs), 2 surgical ICUs, 2 pediatric ICUs and 1 burn ICU with a total of 69 ICU beds. During the study period from 1996 to 2003, patients with NBSIs were enrolled in the study by infection control nurses. NBSI was defined as an episode of bacteremia or fungemia in clinically ill patients with at least 1 set of blood culture drawn at least 48 h after admission and yielding at least 1 pathogen [13]. Patients were classified as having nosocomial coagulase-negative staphylococci bacteremia if there were clinical symptoms and signs compatible with sepsis and 2 concurrent sets of positive blood cultures.

All NBSI isolates were identified by standard methods and the VITEK or API identification system (bioMérieux, Marcy l'Etoile, France). Antimicrobial susceptibility was determined by the disk diffusion method, and interpretive criteria followed the latest National Committee for Clinical Laboratory Standards (NCCLS) recommendations. Intermediate susceptible isolates were classified as being resistant. The confirmatory test for the production of ESBL in *E. coli* and *K. pneumoniae* followed the NCCLS guidelines [14], and was performed since 2000.

Pan-drug-susceptible *P. aeruginosa* was defined as an isolate susceptible to all antipseudomonal agents tested, including piperacillin, piperacillin/tazobactam, ceftazidime, aztreonam, imipenem, meropenem, ciprofloxacin, gentamicin, and tobramycin. Pan-drug-resistant *A. baumannii* was defined as an isolate resistant to all antibiotics tested, including ampicillin-sulbactam, piperacillin/tazobactam, ceftazidime, cefepime, aztreonam, imipenem, meropenem, gentamicin, amikacin, and ciprofloxacin. For *Candida* spp., antifungal susceptibility to fluconazole or amphotericin B was not routinely determined.

To determine the percentage of isolates with antimicrobial resistance, only the first isolate from multiple positive blood cultures was taken into consideration. For convenience of comparison, the ranking of NBSI pathogens and status of antimicrobial resistance were determined in 2 time periods, designated as period I (1996-1999) and period II (2000-2003). The incidence rate was calculated as the number of NBSI episodes per 1000 inpatient-days. The annual consumption of indicated antimicrobial agents, including oral and parenteral forms, was expressed as defined daily dose (DDD) per 1000 inpatient-days. The DDD was defined as the assumed average maintenance dose per day for a drug used for its main indication in adults. The DDDs for each drug examined in this study were as follows: 2 g for parenteral vancomycin, 400 mg teicoplanin, 2 g imipenem/cilastatin, 2 g meropenem, 4 g ceftazidime, 14 g piperacillin/tazobactam, and 0.2 g fluconazole of both oral and parenteral forms.

The significance of differences in frequencies and proportions was determined by 2 tailed chi-squared test. Correlation between the amount of annual consumption of antimicrobial agents and the resistance rate of nosocomial pathogens was analyzed by partial correlation coefficients. A p value less than 0.05 was considered to be statistically significant.

Results

Incidence of pathogens causing NBSIs

The inpatient-days at the hospital increased from 1,009,685 in period I to 1,239,071 in period II, and the total inpatient-days was 2,248,756 during the

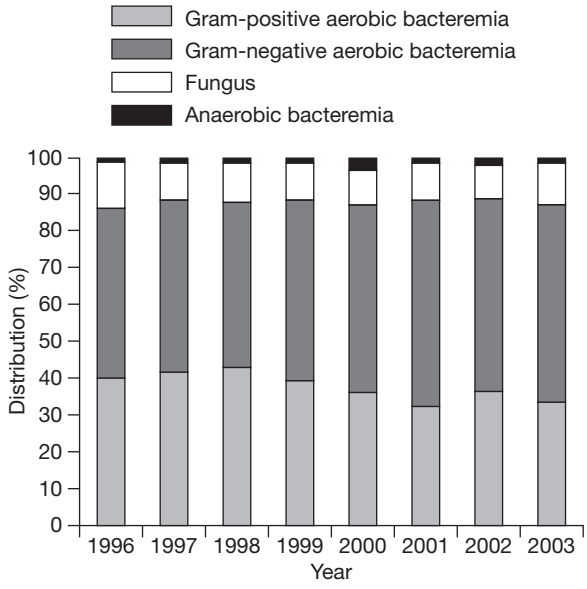

Fig. 1. Distribution of microorganisms causing nosocomial bloodstream infections at a medical center in southern Taiwan, 1996-2003.

8-year period. Overall, 4038 NBSI episodes were identified. The incidence of NBSIs was 1.73 episodes per 1000 inpatient-days for pediatric patients and 1.80 for adult patients. The overall incidence of NBSIs increased from 1.53 episodes per 1000 inpatient-days in period I to 2.01 in period II, with an average of 1.79 episodes per 1000 inpatient-days. In general, the incidence of NBSIs in ICUs was 4 times that in the general wards.

Aerobic Gram-negative bacilli, Gram-positive cocci, fungi, and anaerobes were responsible for 51%, 37%, 10%, and 1.6% of NBSI pathogens, respectively. Aerobic Gram-negative bacilli remained the predominant cause of NBSIs throughout the study period (Fig. 1). The 12 leading pathogens in order of greatest frequency were coagulase-negative staphylococci (16% of all NBSIs pathogens), *S. aureus* (13%), *Candida* spp. (10%), *A. baumannii* (8%), *E. coli* (8%), enterococci (6%), *K. pneumoniae* (6%), *Enterobacter cloacae* (6%), *P. aeruginosa* (5%), *Acinetobacter* spp. (3%), *Stenotrophomonas maltophilia* (3%), and *Serratia marcescens* (2%), as shown in Table 1. The incidences of NBSIs in ICUs were higher than those in general wards (Table 1). The predominance of NBSIs in ICU settings was particularly notable for *S. maltophilia* and *A. baumannii*, for which the incidence in ICUs was 14- and 8-fold, respectively, higher than that in general wards.

Coagulase-negative staphylococci, *S. aureus* and *Enterococcus* spp. together accounted for 93% of aerobic Gram-positive bacteremia and 34% of all NBSI pathogens. Nosocomial enterococcal bacteremia was caused by *Enterococcus faecalis* in 71%, and by *Enterococcus faecium* in 18% of cases. Except for coagulase-negative staphylococci and *S. maltophilia,*

Table 1. Rank order and annual incidence of 12 major pathogens causing nosocomial bloodstream infections (NBSIs) at a medical center in southern Taiwan, 1996-2003

	Rank	Incidence of NBSIs (episodes per 1000 inpatient-days)			Change[a] (%)	Incidence of NBSIs (episodes per 1000 inpatient-days)		Relative risk[b]
		1996-2003, overall	1996-1999	2000-2003		1996-2003 (ICUs)	1996-2003 (wards)	
Coagulase-negative staphylococci	1	0.32	0.32	0.30	-6	0.97	0.24	4.0
Staphylococcus aureus	2	0.28	0.20	0.32	58	0.95	0.20	4.8
Candida spp.	3	0.22	0.17	0.24	47	0.81	0.14	5.6
Acinetobacter baumannii	4	0.18	0.12	0.22	91	0.83	0.10	8.2
Escherichia coli	5	0.16	0.12	0.19	59	0.23	0.15	1.5
Enterococcus spp.	6	0.13	0.08	0.17	105	0.46	0.10	4.8
Klebsiella pneumoniae	7	0.13	0.07	0.17	137	0.38	0.10	3.7
Enterobacter cloacae	8	0.12	0.09	0.15	71	0.52	0.08	6.8
Pseudomonas aeruginosa	9	0.11	0.08	0.13	64	0.39	0.08	4.9
Acinetobacter spp.	10	0.06	0.04	0.08	122	0.21	0.04	4.7
Stenotrophomonas maltophilia	11	0.05	0.05	0.05	5	0.30	0.02	14.0
Serratia marcescens	12	0.04	0.02	0.06	285	0.16	0.03	5.6

[a]Percentage change from 1996-1999 to 2000-2003.

[b]Relative risk: incidence of NBSIs in intensive care units (ICUs)/incidence of NBSIs in non-ICU wards.

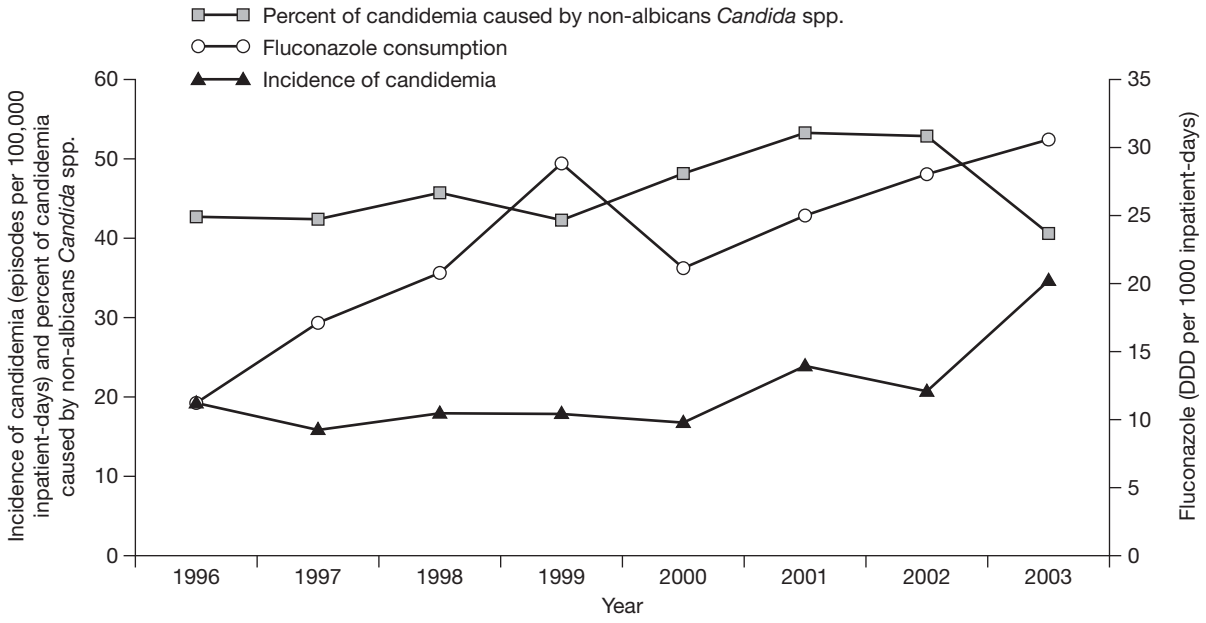

Fig. 2. Temporal correlation between the incidence of nosocomial candidemia, proportion of candidemia caused by non-albicans *Candida* spp., and the amount of fluconazole prescribed, quantified by the defined daily dose (DDD) per 1000 inpatient-days, at a medical center in southern Taiwan, 1996-2003.

the incidences of NBSIs caused by the remaining 10 pathogens increased between periods I and II, with an increment ranging from 47% to 285%. An increment of more than 100% in NBSI incidence was noted for *S. marcescens, K. pneumoniae*, *Acinetobacter* spp., and *Enterococcus* spp. (Table 1). Interestingly, the incidence of *Chryseobacterium meningosepticum* increased markedly from 0.006 episodes per 1000 inpatient-days in period I to 0.03 episodes per 1000 inpatient-days in period II, an increment of 382%.

Nosocomial fungemia was caused by *Candida* spp. in 97% of episodes. *C. albicans* was the most common *Candida* spp., accounting for 54% of nosocomial candidemia (Fig. 2), followed by *Candida tropicalis* (24%), *Candida parapsilosis* (11%), *Candida glabrata* (7%) and other *Candida* spp. (4%). *C. albicans*, *C. tropicalis*, together with *C. parapsilosis* were responsible for about 90% of nosocomial candidemia.

Trends of antimicrobial susceptibility

Analysis of the trend of antimicrobial resistance among the leading pathogens causing NBSIs in the 2 study periods revealed that an average of 90% of coagulase-negative *Staphylococcus* isolates and 75% of *S. aureus* isolates were resistant to oxacillin (Fig. 3). Ampicillin resistance was seen in 1% of *E. faecalis* and 78% of *E. faecium* isolates, while high-level gentamicin resistance was found in 58% of *E. faecalis* and 72% of *E. faecium*. Except for 1 enterococci isolate in 1999, vancomycin remained active against all staphylococci and enterococci isolates throughout the study period.

An increment of antimicrobial resistance between the 2 periods was seen in the majority of Gram-negative bacteria causing NBSIs in our hospital. Significant

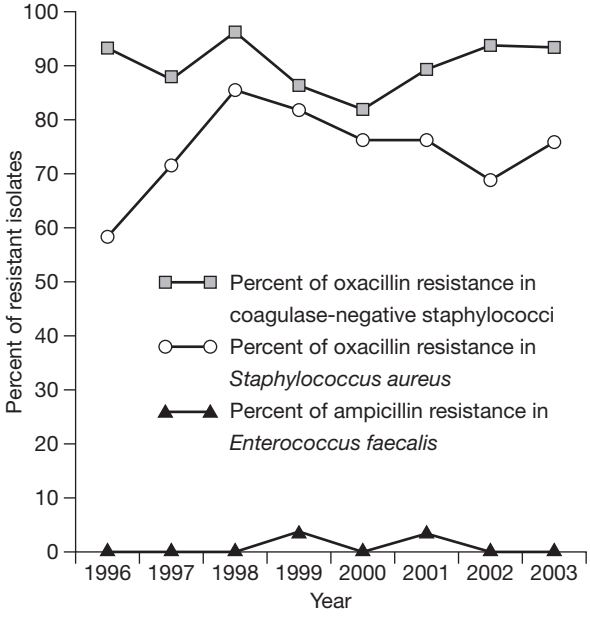

Fig. 3. Rates of antimicrobial resistance among 3 major Gram-positive cocci causing nosocomial bacteremia in a medical center in southern Taiwan, 1996-2003.

Table 2. Antimicrobial resistance of 3 non-fermentative Gram-negative bacteria spp. causing nosocomial bloodstream infections during 1996-1999 and 2000-2003

Antimicrobial agent	Resistance rate, 1996-1999/2000-2003 (total)		
	Acinetobacter baumannii	*Pseudomonas aeruginosa*	*Stenotrophomonas maltophilia*
Isolate no., 1996-1999/2000-2003 (total)	129/281 (410)	90/168 (258)	57/66 (123)
Ceftazidime (%)	29/37 (34)	12/9 (10)	55/63 (59)
Ciprofloxacin (%)	32/48[a] (43)	17/11 (13)	52/53 (52)
Imipenem or meropenem (%)	2/14[a] (10)	7/9 (8)	-/-
Piperacillin/tazobactam (%)	40/52[a] (49)	11/9 (9)	-/-
Ticarcillin/clavunate (%)	-/-	-/-	8/18[b] (14)
Co-trimoxazole (%)	-/-	-/-	52/33[a] (42)

[a]$p<0.05$ (1996-1999 vs 2000-2003).
[b]2000-2002.

increments were found in antimicrobial resistance of *A. baumannii* to ciprofloxacin, carbapenem, or piperacillin/tazobactam during the 2 study periods (period I vs period II, $p<0.05$) [Table 2], and to cephalothin, cefotaxime/ceftriaxone or fluoroquinolone in *E. coli* (Table 3). Increasing resistance of *E. coli* to third-generation cephalosporins was at least partially related to the presence of ESBL, which was routinely examined and discovered in 6% of *E. coli* and 11% of *K. pneumoniae* since 2000. *E. coli* isolates had higher rates of resistance to cephalothin (68% vs 35%, $p<0.001$) and fluoroquinolone (47% vs 32%, $p<0.001$) than *K. pneumoniae*, while more *K. pneumoniae* isolates had higher rates of resistance to fourth-generation cephalosporins than *E coli* (8% vs 2%, $p=0.04$). More isolates of *A. baumannii* were resistant to ciprofloxacin, piperacillin/tazobactam or carbapenems in period II than in period I (Table 2). Moreover, 5 isolates of pan-drug-resistant *A. baumannii* were identified in period II. In contrast, antimicrobial susceptibilities to piperacillin/tazobactam, ceftazidime, ciprofloxacin, and carbapenems in *P. aeruginosa* remained stable throughout the study period. The proportion of pan-drug susceptibility among *P. aeruginosa* isolates, however, significantly increased (56% in period I vs 72% in period II; $p=0.01$).

Temporal correlation between antimicrobial consumption and susceptibility

No temporal correlation was found between consumption of and resistance to carbapenems in *A. baumannii* ($r = –0.25$, $p<0.001$) or *P. aeruginosa* ($r = –0.65$, $p<0.001$) isolates, or consumption of and resistance to ceftazidime in these isolates ($r = –0.23$, $p<0.001$; $r = –0.58$, $p<0.001$, respectively). However, a positive correlation between the prescribed dosage of piperacillin/tazobactam and piperacillin/tazobactam-resistance was found in both *A. baumannii* (r = 0.51,

Table 3. Antimicrobial resistance of 4 Gram-negative bacteria spp. of *Enterobacteriaceae* causing nosocomial bloodstream infections during 1996-1999 and 2000-2003

Antimicrobial agent	Resistant rate, 1996-1999/2000-2003 (Total)			
	Escherichia coli	*Klebsiella pneumoniae*	*Enterobacter cloacae*	*Serratia marcescens*
Isolate no., 1996-1999/2000-2003 (total)	135/244 (379)	87/219 (306)	103/293 (396)	18/81 (99)
Cephalothin (%)	61/72[b] (68)	33/36 (35)	-/-	-/-
Ceftriaxone or cefotaxime (%)	3/17[b] (12)	15/18 (17)	44/50 (48)	6/21 (18)
Cefepime or cefpirome (%)	-/2[c]	-/8[c]	-/9[d]	-/9[d]
Fluoroquinolone[a] (%)	50/46 (47)	24/35 (32)	13/15 (14)	33/59 (54)
Imipenem or meropenem (%)	-/-	-/-	0/0 (0)	0/0 (0)

[a]Including lomefloxacin, pefloxacin, ciprofloxacin, or ofloxacin.
[b]$p<0.05$ (1996-1999 vs 2000-2003).
[c]2002-2003.
[d]2001-2003.

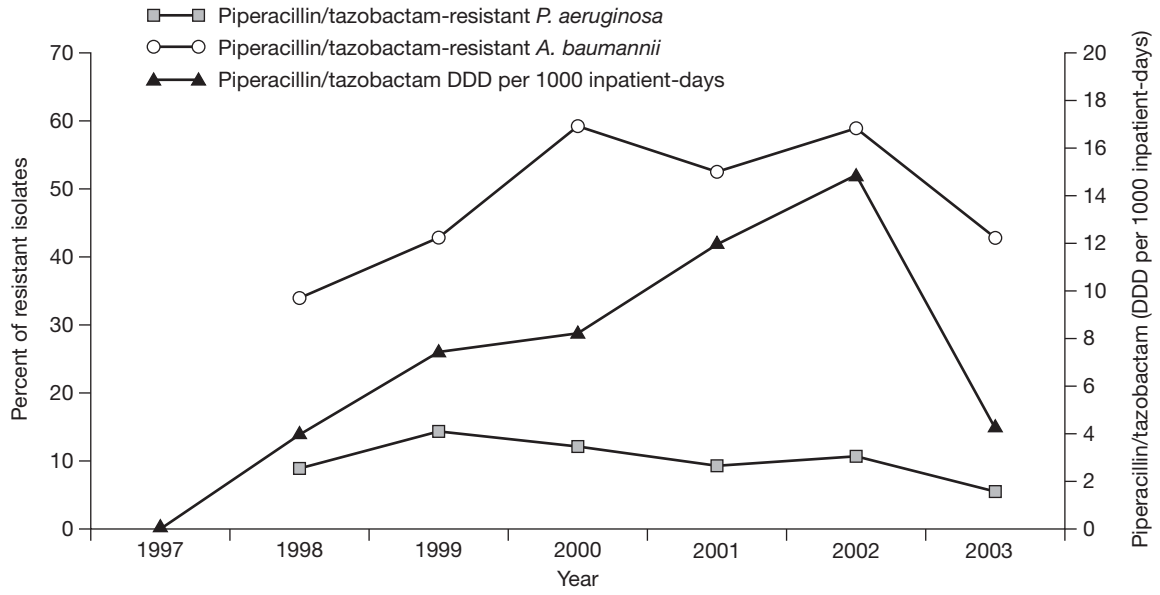

Fig. 4. Trends of antimicrobial susceptibility to piperacillin/tazobactam in nosocomial bacteremic *Pseudomonas aeruginosa* and *Acinetobacter baumannii* isolates at a medical center in southern Taiwan, 1996-2003. Correlation between annual defined daily dose (DDD) of piperacillin/tazobactam and resistance rates was noted for *P. aeruginosa* (r = 0.51, $p<0.001$) and *A. baumannii* (r = 0.98, $p<0.001$).

$p<0.001$) and *P. aeruginosa* ($r = 0.98$, $p<0.001$) [Fig. 4].

Although the incidence of nosocomial candidemia and annual consumption of fluconazole increased gradually, candidemia caused by non-albicans *Candida* spp. did not increase accordingly, as demonstrated by the negative correlation between annual consumption of fluconazole and the proportion of candidemia caused by non-albicans spp. ($r = –0.27$, $p<0.001$) [Fig. 2].

Discussion

The trend of increase in NBSIs during this study period is in agreement with similar findings reported worldwide [5,10,15]. The increase in the rate of NBSIs may be attributable to several factors, including increases in the number of debilitated or immunocompromised patients, and the use of invasive procedures or instrumentations in health care facilities [16-20]. These factors were likely to have played an important role in the 4-fold increase of NBSI incidences in ICUs compared with that in general wards in this study. Higher incidences of NBSIs subsequently led to the widespread use of broad-spectrum antimicrobial agents, which further promoted the emergence of antimicrobial-resistant pathogens. Strategies to lower the incidence of nosocomial infections and antimicrobial resistance which have been implemented in our hospital include decreased use of invasive procedures or instrumentations, encouraging frequent hand washing, and restriction of antibiotics use.

In the present study, 9.5% of NBSI episodes were caused by fungus, mainly *Candida* spp. These results are similar to the findings of a nationwide surveillance study conducted in the United States during 1995-2002 (9.5%) [21]. However, Gram-positive cocci predominated in the study from the United States, comprising 65% of causative organisms in NBSI episodes [21], while aerobic Gram-negative organisms were responsible for nearly a half of NBSIs in our hospital. A similar shift in pathogen distribution has also been reported in bacteremic episodes in febrile neutropenic patients [22] and in septicemic patients from a nationwide, large-scale epidemiological survey in the United States [23]. The cause of the delay in the evolution of major pathogens in NBSIs in Taiwan remains to be clarified.

Several differences were found between nosocomial bacteremia caused by *E. faecalis and E. faecium.* First, *E. faecalis*, the most frequent spp. isolated from human stool, accounted for 71% of nosocomial enterococcal bacteremia, and *E. faecium* only 18%. Second, a striking increase in intrinsic resistance to penicillin among *E. faecium* was found, although there has been little change in the intrinsic resistance of *E. faecalis* to

penicillins, in accordance with the earlier findings [24]. *E. faecium* was more resistant to ampicillin than *E. faecalis* both in the present study and in data from Taiwan Surveillance of Antimicrobial Resistance (TSAR) surveillance II [25]. In contrast, there was no significant difference in high level gentamicin resistance between *E. faecalis* and *E. faecium* both in this study (72% vs 58%, p=0.06) and in data from TSAR surveillance II (66% vs 62%) [25].

Oxacillin resistance, a common resistant phenotype among nosocomial *Staphylococcus* isolates, was seen in 75% of *S. aureus* and 90% of coagulase-negative staphylococci in this study. In previous decades, bloodstream isolates of staphylococci were not resistant to vancomycin by disk diffusion susceptibility test.

VRE emerged in the United Status in 1988 [24]. In Taiwan, the first VRE isolate was reported in 1996 from a urine specimen in a medical center in northern Taiwan, and thereafter, bloodstream infections caused by VRE were found occasionally [26]. However, only 1 VRE isolate was found in patients with bloodstream infections in this study. Overall, the prevalence of vancomycin resistance in enterococci of about 3% in our country as reported by the TSAR surveillance II [25] was low compared with the United Status, where vancomycin resistance was found in 30.6% of enterococci in 1997 [27] and in 2% of *E. faecalis* isolates and 60% of *E. faecium* isolates in 2004 [21]. The more limited use of vancomycin of 15.5 DDD/1000 inpatient-days in our hospital compared to that in United States, which ranged from 27.1 DDD in non-ICU patients to more than 60 DDD in ICU patients [28], might partially explain the lower incidence of nosocomial VRE infections in Taiwan.

An increase of antimicrobial resistance among major Gram-negative bacteria was found in our hospital during the study period, particularly resistance to ciprofloxacin, carbapenem, or piperacillin/tazobactam in *A. baumannii*; cephalothin, cefotaxime/ceftriaxone or fluoroquinolone in *E. coli*, ESBL-producing *E. coli* and *K. pneumoniae*. One of the major concerns about Gram-negative bacillary pathogens is the emergence of ESBL-producing strains, which are resistant to all β-lactam agents, except cephamycins and carbapenems. In general, ESBL production is more common in *K. pneumoniae* and *E. coli*, as was found in in this study (11% vs 6%) and in TSAR II surveillance II study (13% vs 4%) [7].

In a previous study, cefotaxime resistance was not uncommon in nosocomial *S. marcescens* (36-68%) and *E. cloacae* (44-69%) isolates in Taiwan [5]. In addition to carbapenems, fourth-generation cephalosporins were active against more than 90% of both spp. A discrepancy in fluoroquinolone resistance in isolates of *S. marcescens* and *E. cloacae* has been previously reported, with more isolates of the former showing fluoroquinolone-resistance than those of the latter, as confirmed in this study (54% vs 14%) and in TSAR II (51% vs 10%) [7]. Although *P. aeruginosa* isolates showed a remarkable increase in resistance to ciprofloxacin, ceftazidime and imipenem in different surveillance studies [29,30], this was not observed in our study, in which the rate of resistance to these 3 agents was about 10% during 2000-2003. Furthermore, the proportion of pan-drug-susceptible *P. aeruginosa* increased from 56% to 72% during the study. The reasons for the increase in pan-drug susceptibility remain unclear.

Although carbapenems have been the most active antimicrobials against *A. baumannii* in the past, resistance to carbapenems has surged, with such a trend found in distinct geographic regions [9,31-33]. The emergence of carbapenem-resistant or pan-drug-resistant *A. baumannii* creates a therapeutic challenge, and was considered a harbinger of the postantibiotic era [9].

Despite the widespread use of fluconazole in Taiwan since 1990, increasing susceptibility of non-krusei *Candida* blood isolates to fluconazole has been observed in Taiwan [34]. Moreover, about 90% of nosocomial candidemias in our hospital were caused by *C. albicans, C. tropicalis,* or *C. parapsilosis*, all presumed to be susceptible to fluconazole [34,35]. Therefore, fluconazole is still considered appropriate empirical therapy for candidemia in Taiwan.

The impact of antimicrobial use on the antimicrobial susceptibility of nosocomial pathogens has been studied extensively [36-39]. However, no positive correlation was found between annual consumption of carbapenems and carbapenem-resistant rates in *A. baumannii* or *P. aeruginosa*, or between ceftazidime use and ceftazidime-resistant rates in both spp. in our hospital. In contrast, positive temporal correlations were found between piperacillin/tazobactam usage and piperacillin/tazobactam resistance rates in *A. baumannii* and *P. aeruginosa*. These data suggest the complex nature of interactions between pharmaceutic factors, host factors and microbiological characteristics in the evolution of antimicrobial resistance in a hospital.

In summary, the incidence of NBSIs and antimicrobial resistance of most causative pathogens increased during a recent 8-year period in our hospital.

Surveillance of NBSI incidences and antimicrobial resistance provides an essential guide for empirical therapy. Thus, surveillance programs, together with rigorous antibiotic control and infection control measures, need to be improved to reduce the incidence of nosocomial infections and antimicrobial resistance.

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