

Community-Acquired versus Nosocomial *Klebsiella pneumoniae* Bacteremia: Clinical Features, Treatment Outcomes, and Clinical Implication of Antimicrobial Resistance

We conducted this study to compare clinical features, outcomes, and clinical implication of antimicrobial resistance in *Klebsiella pneumoniae* bacteremia acquired as community vs. nosocomial infection. A total of 377 patients with *K. pneumoniae* bacteremia (191 community-acquired and 186 nosocomial) were retrospectively analyzed. Neoplastic diseases (hematologic malignancy and solid tumor, 56%) were the most commonly associated conditions in patients with nosocomial bacteremia, whereas chronic liver disease (35%) and diabetes mellitus (20%) were the most commonly associated conditions in patients with community-acquired bacteremia. Bacteremic liver abscess occurred almost exclusively in patients with community-acquired infection. The overall 30-day mortality was 24% (91/377), and the mortality of nosocomial bacteremia was significantly higher than that of community-acquired bacteremia (32% vs. 16%, $p < 0.001$). Of all community-acquired and nosocomial isolates, 4% and 33%, respectively, were extended-spectrum cephalosporin (ESC)-resistant, and 4% and 21%, respectively, were ciprofloxacin (CIP)-resistant. In nosocomial infections, prior uses of ESC and CIP were found to be independent risk factors for ESC and CIP resistance, respectively. Significant differences were identified between community-acquired and nosocomial *K. pneumoniae* bacteremia, and the mortality of nosocomial infections was more than twice than that of community-acquired infections. Antimicrobial resistance was a widespread nosocomial problem and also identified in community-acquired infections.

Key Words : *Klebsiella pneumoniae*; Bacteremia; Treatment Outcome; Risk Factors; Drug Resistance, Microbial

Cheol-In Kang*, Sung-Han Kim*,
Ji-Whan Bang*, Hong-Bin Kim*,
Nam-Joong Kim*, Eui-Chong Kim^{†,‡},
Myoung-don Oh^{†,‡}, Kang-Won Choe^{*,†},

Departments of Internal Medicine* and Laboratory
Medicine[†], Seoul National University College of
Medicine; Clinical Research Institute[‡], Seoul National
University Hospital, Seoul, Korea

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Address for correspondence

Myoung-don Oh, M.D.
Department of Internal Medicine, Seoul National
University College of Medicine, 28 Yongon-dong,
Chongno-gu, Seoul 110-744, Korea
Tel : +82.2-2072-2945, Fax : +82.2-762-9662
E-mail : mdohmd@snu.ac.kr

INTRODUCTION

Klebsiella pneumoniae is a very important cause of morbidity and mortality in Gram-negative bacteremia (1). It is a common nosocomial pathogen, causing urinary tract infections, pneumonia, and intraabdominal infections (1-4). In a past decade, the emergence of extended-spectrum beta-lactamases (ESBL) in *K. pneumoniae* strains and their dissemination have greatly complicated chemotherapy, and outbreak due to ESBL-producing organisms have been reported in several countries (5-7). Ciprofloxacin (CIP) resistance rate in *K. pneumoniae* strains is also increasing in recent years (7-9).

K. pneumoniae is also a potential community-acquired pathogen. A previous international collaborative study evaluated geographic differences and trends in the prominent presentations of community-acquired *Klebsiella* infection (10). A striking clinical finding concerning a new manifestation of community-acquired *K. pneumoniae* infections has been documented (10). An unusual invasive presentation of *K. pneumoniae* infection, primary bacteremic liver abscess, has been

described by numerous investigators in Asia (1, 10, 11). However, little data were available on the clinical and microbiological characteristics of nosocomial vs. community-acquired *K. pneumoniae* bacteremia in the era of a high rate of antimicrobial resistance.

In the present study, we thus describe a recent five-year survey of *K. pneumoniae* bacteremia, with a high rate of antimicrobial resistance, and the clinical-epidemiological features of 377 patients. We conducted this study to compare the clinical features, treatment outcomes, and clinical implication of antimicrobial resistance in *K. pneumoniae* bacteremia acquired as community versus nosocomial infection.

MATERIALS AND METHODS

Patients and bacterial strains

The database at our Clinical Microbiology Laboratory (Seoul National University Hospital, Seoul, Korea) was reviewed

in order to identify patients with *K. pneumoniae* bacteremia. Patients older than 16 yr of age with *K. pneumoniae* bacteremia were included in the analysis. Only the first bacteremic episode for each patient was included in the analysis. We reviewed the medical records of individuals diagnosed from January 1998 to December 2002 at Seoul National University Hospital, Seoul, Korea, a 1,500-bed tertiary care university hospital and referral center.

Species identification was carried out with Vitek-GNI Card (bioMérieux, Hazelwood, MO, U.S.A.) by standard methods, and antibiotic susceptibility testing was performed using the disk diffusion method, following the recommendations of the National Committee for Clinical Laboratory Standards (12). Strains showing inhibition zone diameters in the intermediate range were considered resistant.

Study design and data collection

A retrospective observational cohort study was conducted to evaluate clinical features, treatment outcomes, and clinical implication of antimicrobial resistance in *K. pneumoniae* bacteremia. We compared data from patients with community-acquired *K. pneumoniae* bacteremia with data from those with nosocomial bacteremia.

We reviewed the medical records of the patients. The data collected included age, gender, underlying diseases, primary sites of infection, severity of illness as calculated by the Acute Physiology and Chronic Health Evaluation (APACHE) II score (13), and the antimicrobial therapy regimen. The presence of the following comorbid conditions was also documented: neutropenia, presentation with septic shock, care in intensive care unit (ICU), receipt of immunosuppressive agents within 30 days prior to onset of the bacteremia, corticosteroid use, the presence of a central venous catheter or of an indwelling urinary catheter, and post-operative state. The main outcome measure used was the 30-day mortality rate.

Definitions

K. pneumoniae bacteremia was defined as the isolation of *K. pneumoniae* in a blood culture specimen. Onset of bacteremia was defined as the date when the first positive blood culture was obtained. Extended-spectrum cephalosporins (ESC) resistance was defined as resistance in vitro to cefotaxime or ceftazidime. The antimicrobial therapies were classified into empirical and definitive, the former being defined as the initial therapy before the results of blood culture were available, and the latter as therapy after the result of antibiotic susceptibility tests had been received. The antimicrobial therapy was considered 'appropriate' if the treatment regimen included at least one antimicrobial agent active in vitro against *K. pneumoniae*, and if the dosage and route of administration conformed to current medical standards. We considered antimicrobial therapy to be 'inappropriate' if the drugs used did not

have in vitro activity against the isolated strain or if the patient did not receive antimicrobial therapy. The bacteremia was categorized as polymicrobial if additional microorganisms were recovered from the blood cultures. Nosocomial infection was defined as an infection that occurred ≥ 48 hr after hospital admission; an infection that occurred <48 hr after admission to the hospital, in patients that had been hospitalized in the 2 weeks prior to admission; and an infection that occurred <48 hr after admission to the hospital in patients that had been transferred from another hospital or nursing home. The primary site of infection was determined using clinical criteria and isolation of the bacteremic organism from sources other than blood (14). Neutropenia was defined as an absolute neutrophil count below $500/\mu\text{L}$. Septic shock was defined as sepsis associated with evidence of organ hypoperfusion and a systolic blood pressure <90 or >30 mmHg less than the baseline or a requirement for the use of vasopressor to maintain blood pressure.

Statistical analysis

The Student's *t*-test was used to compare continuous variables, and χ^2 or Fisher's exact test to compare categorical variables. In identifying the independent risk factors, a backward stepwise logistic regression analysis was used to control for the effects of confounding variables. Variables with a *p*-value <0.1 in the univariate analysis were candidates for multivariate analysis. We used backward elimination of any variable that did not contribute to the model on the grounds of the likelihood ratio test, using a significance cutoff of 0.05. All *p*-values were two-tailed, and *p*-values <0.05 were considered statistically significant. The SPSS for Windows, version 11.5 software package (SPSS Inc, Chicago, IL, U.S.A.), was used for all analyses.

RESULTS

Study population and clinical characteristics

Three hundred and seventy-seven consecutive patients with *K. pneumoniae* bacteremia were included in this analysis. Among these, 191 cases were classified to be community-acquired infection and the remaining 186 cases were classified to be nosocomial infection. The demographic and clinical characteristics of both groups are shown in Table 1.

As for the underlying diseases, diabetes mellitus was more common in community-acquired than in nosocomial infection (20.4% vs. 4.3%, $p<0.001$). Hematologic malignancy was more frequently noted in patients with nosocomial compared with community-acquired infection (28% vs. 4.7%, $p<0.001$). Prior use of antibiotics, inappropriate antimicrobial therapy, central venous catheterization, indwelling urinary catheter, and neutropenia were more frequent in noso-

Table 1. Demographic characteristics and underlying conditions of patients with community-acquired vs. nosocomial *K. pneumoniae* bacteremia

	Community-acquired (n=191)	Nosocomial (n=186)	<i>p</i>
Age, mean yr ± SD (range)	57 ± 13 (17-86)	53 ± 13 (17-87)	0.003
Male	126 (66)	123 (66.1)	0.974
Underlying diseases			
None	12 (6.3)	1 (0.5)	0.002
Diabetes mellitus	39 (20.4)	8 (4.3)	<0.001
Benign pancreaticobiliary tract disease	24 (12.6)	7 (3.8)	0.002
Hematologic malignancy	9 (4.7)	52 (28.0)	<0.001
Solid tumor	45 (23.6)	52 (28.0)	0.329
Chronic liver disease	67 (35.1)	55 (29.6)	0.253
Primary site of infection			
Pancreaticobiliary tract	50 (26.2)	39 (21.0)	0.234
Liver	21 (11.0)	4 (2.2)	0.001
Lung	10 (5.2)	11 (5.9)	0.774
Urinary tract	20 (10.5)	12 (6.5)	0.162
Peritoneum	39 (20.4)	43 (23.1)	0.524
Unknown	49 (25.7)	76 (40.9)	0.002
Prior antibiotics use	14 (7.3)	91 (48.9)	<0.001
Inappropriate empirical antibiotics	4 (2.1)	29 (15.6)	<0.001
Inappropriate definitive antibiotics	0 (0)	13 (7.0)	<0.001
Central line catheterization	5 (2.6)	61 (32.8)	<0.001
Indwelling urinary catheter	7 (3.7)	33 (17.7)	<0.001
Neutropenia	18 (9.4)	52 (28.0)	<0.001
CIP resistance	8 (4.2)	39 (21.0)	<0.001
ESC resistance	7 (3.7)	62 (33.3)	<0.001
Presentation with septic shock	42 (22.0)	50 (26.9)	0.269
APACHE II score, mean ± SD (range)	9.80 ± 5.08 (0-28)	11.75 ± 4.52 (2-25)	<0.001

Data represent patient numbers (%), otherwise indicated. SD, standard deviation; CIP, ciprofloxacin; ESC, extended-spectrum cephalosporins; APACHE, acute physiology and chronic health evaluation.

comial infection (All $p < 0.05$, Table 1). Also, the mean APACHE II score was higher in nosocomial infection (11.75 ± 4.52 vs. 9.80 ± 5.08 , $p < 0.001$).

As for the primary site of infection, liver abscess were predominant in community-acquired infection. Among these ($n=21$), 8 cases were identified to have disseminated infection with metastatic infection, whereas no case in nosocomial infections was identified to have disseminated infection. Primary site of infection was unknown in 76 (40.9%) cases of nosocomial bacteremia, whereas in 49 (25.7%) cases of community-acquired bacteremia ($p=0.002$) (Table 1).

Clinical outcomes and risk factors for mortality

The overall 30-day mortality rate of *K. pneumoniae* bacteremia was 24.1% (91/377) and the mortality of nosocomial infections was significantly higher than that of community-acq-

Table 2. Treatment outcome of patients with community-acquired vs. nosocomial *K. pneumoniae* bacteremia

	Community-acquired (n=191)	Nosocomial (n=186)	<i>p</i>
Treatment failure rate at 72 hr			
Clinical failure*	35 (18.3%)	69 (37.1%)	<0.001
Microbiological failure [†]	3 (1.6%)	14 (7.5%)	0.005
7-day mortality	18 (9.4%)	38 (20.4%)	0.003
30-day mortality	31 (16.2%)	60 (32.3%)	<0.001

Data represent patient numbers (%).

*Absence of abatement or deterioration in any clinical parameters associated with infection at 72 hr after initial antimicrobial therapy, [†]Isolation of the organism in follow-up blood culture.

quired infections (32.3% [60/186] vs. 16.2% [31/191], $p < 0.001$) (Table 2). Factors associated with 30-day mortality are shown in Table 3. From the univariate analysis, the significantly associated factors were; inappropriate empirical antibiotics, inappropriate definitive antibiotics, ESC resistance, ICU care, septic shock at initial presentation, neutropenia, corticosteroid use, immunosuppressant use, nosocomial acquisition, long hospital stay, pneumonia, and peritonitis (all $p < 0.05$) (Table 3). Pancreaticobiliary tract infection and liver abscess were more common in survival group (Table 3).

Multivariate analysis using a logistic regression model, which included the variables associated with mortality by univariate analysis ($p < 0.1$), showed that nosocomial acquisition was one of the independent risk factors associated with 30-day mortality (OR=2.32, 95% CI=1.11-4.86, $p=0.025$). Inappropriate definitive antibiotics, having peritonitis, having pneumonia, unknown site of infection, septic shock at initial presentation, and increased APACHE II score were also independent risk factors of mortality in overall *K. pneumoniae* bacteremia cases (Table 4). When assessed the significant independent factors associated with mortality in cases of community-acquired infection, presentation with septic shock and increased APACHE II score were also found to be independent risk factors. Pancreaticobiliary tract infection was found to be associated with survival (OR, 0.20; 95% CI, 0.05-0.82; $p=0.026$). In cases of nosocomial infection, inappropriate definitive antibiotics as well as presentation with septic shock and increased APACHE II score were found to be independent risk factors.

Clinical implication of antimicrobial resistance

Among 186 cases with nosocomial infection, 62 (33.3%) cases were infected by ESC-resistant isolates, and 39 (21.0%) cases were infected by CIP-resistant isolates. The ESC resistance was detected in 35 (89.7%) of the 39 CIP-resistant *K. pneumoniae* isolates. In comparison, only 27 (18.4%) of the 147 CIP-susceptible isolates were resistant to ESC ($p < 0.001$). No nosocomial isolate in this study was identified to be resis-

Table 3. Risk factors associated with 30-day mortality in patients with *K. pneumoniae* bacteremia [Univariate analysis]

	Overall			Community-acquired (n=191)			Nosocomial (n=186)		
	Survivors (n=286)	Non-survivors (n=91)	<i>p</i>	Survivors (n=160)	Non-survivors (n=31)	<i>p</i>	Survivors (n=126)	Non-survivors (n=60)	<i>p</i>
Inappropriate empirical antibiotics	17 (5.9)	16 (17.6)	0.001	2 (1.3)	2 (6.5)	0.124	15 (11.9)	14 (23.3)	0.045
Inappropriate definitive antibiotics	3 (1.0)	10 (11.0)	<0.001		N.C.		3 (2.4)	10 (16.7)	<0.001
ESC resistance	46 (16.1)	23 (25.3)	0.048	5 (3.1)	2 (6.5)	0.318	41 (32.5)	21 (35.0)	0.739
CIP resistance	33 (11.5)	14 (15.4)	0.333	7 (4.4)	1 (3.2)	0.770	26 (20.6)	13 (21.7)	0.872
ICU care	5 (1.7)	9 (9.9)	<0.001		N.C.		5 (4.0)	9 (15.0)	0.014
Septic shock at initial presentation	27 (9.4)	65 (71.4)	<0.001	20 (12.5)	22 (71.0)	<0.001	7 (5.6)	43 (71.7)	<0.001
Neutropenia	46 (16.1)	24 (26.4)	0.028	12 (7.5)	6 (19.4)	0.084	34 (27.0)	18 (30.0)	0.668
Polymicrobial	30 (10.5)	10 (11.0)	0.893	17 (10.6)	3 (9.7)	0.875	13 (10.3)	7 (11.7)	0.781
Corticosteroid use	26 (9.1)	18 (19.8)	0.006	4 (2.5)	4 (12.9)	0.025	22 (17.5)	14 (23.3)	0.343
Immunosuppressant use	8 (2.8)	8 (8.8)	0.031	3 (1.9)	3 (9.7)	0.055	5 (4.0)	5 (8.3)	0.296
Nosocomial acquisition	126 (44.1)	60 (65.9)	<0.001		---			---	
Long hospital stay (>14 days)*	65 (22.7)	37 (40.7)	0.001		N.C.		65 (51.6)	36 (60.0)	0.282
Underlying diseases									
Hematologic malignancy	43 (15.0)	18 (19.8)	0.284	5 (3.1)	4 (12.9)	0.040	38 (30.2)	14 (23.3)	0.332
Solid tumor	70 (24.5)	27 (29.7)	0.323	35 (21.9)	10 (32.3)	0.212	35 (27.8)	17 (28.3)	0.937
Chronic liver disease	92 (32.2)	30 (33.0)	0.887	57 (35.6)	10 (32.3)	0.719	35 (27.8)	20 (33.3)	0.438
Pancreaticobiliary tract disease	30 (10.5)	1 (1.1)	0.005	24 (15.0)	0 (0)	0.016	6 (4.8)	1 (1.7)	0.432
Diabetes mellitus	37 (12.9)	10 (11.0)	0.624	32 (20.0)	7 (22.6)	0.744	5 (4.0)	3 (5.0)	0.714
Primary site of infection									
Pneumonia	10 (3.5)	11 (12.1)	0.002	4 (2.5)	6 (19.4)	0.002	6 (4.8)	5 (8.3)	0.337
Pancreaticobiliary tract infection	77 (26.9)	12 (13.2)	0.007	47 (29.4)	3 (9.7)	0.022	30 (23.8)	9 (15.0)	0.168
Liver abscess	24 (8.4)	1 (1.1)	0.015	20 (12.5)	1 (3.2)	0.208	4 (3.2)	0 (0)	0.307
Peritonitis	54 (18.9)	28 (30.8)	0.017	32 (20.0)	7 (22.6)	0.744	22 (17.5)	21 (35.0)	0.008
Urinary tract infection	30 (10.5)	2 (2.2)	0.013	19 (11.9)	1 (3.2)	0.207	11 (8.7)	1 (1.7)	0.107
Unknown	88 (30.8)	37 (40.7)	0.081	36 (22.5)	13 (41.9)	0.023	52 (41.3)	24 (40.0)	0.869

Data represent patient numbers (%), otherwise indicated.

N.C., No Cases identified; ESC, extended-spectrum cephalosporins; CIP, ciprofloxacin; ICU, intensive care unit.

*Hospital stay prior to onset of bacteremia.

Table 4. Independent risk factors for mortality in patients with *K. pneumoniae* bacteremia [Multivariate analysis]

Risk factors	Adjusted OR (95% CI)	<i>p</i>
In overall		
Peritonitis	3.66 (1.27-10.54)	0.016
Pneumonia	8.58 (2.22-33.20)	0.002
Unknown site of infection	5.05 (1.77-14.40)	0.002
Nosocomial acquisition	2.32 (1.11-4.86)	0.025
Inappropriate definitive antibiotics	19.29 (2.76-134.96)	0.003
Presentation with septic shock	27.11 (12.47-58.96)	<0.001
Increased APACHE II score (per 1-point increments)	1.15 (1.05-1.26)	0.002
In community-acquired infections		
Presentation with septic shock	18.02 (6.34-51.24)	<0.001
Increased APACHE II score (per 1-point increments)	1.11 (1.01-1.22)	0.031
Pancreaticobiliary tract infection	0.20 (0.05-0.82)	0.026
In nosocomial infections		
Inappropriate definitive antibiotics	19.37 (2.61-143.75)	0.004
Presentation with septic shock	40.31 (13.17-123.42)	<0.001
Increased APACHE II score (per 1-point increments)	1.28 (1.12-1.46)	<0.001

APACHE, acute physiology and chronic health evaluation.

tant to imipenem.

Among 191 cases with community-acquired infection, only 7 (3.7%) cases and 8 (4.2%) cases were infected by ESC-resistant and CIP-resistant isolates, respectively. Of 8 community-acquired isolates which were resistant to CIP, 3 isolates were also resistant to ESC. All community-acquired isolates in this study were susceptible to imipenem and amikacin. All patients with community-acquired infection caused by ESC-resistant *K. pneumoniae* had underlying illness and risk factors for infection by resistant organisms, such as prior hospitalization, prior use of antibiotics, or indwelling catheters. Of 7 cases infected by ESC-resistant isolates, 3 cases had the previous receipt of cephalosporin within 30 days

In nosocomial infection cases, we assessed the risk factors for antimicrobial resistance. For ESC resistance, the significantly associated factors were; ICU care, post-surgical state, indwelling urinary catheter, invasive procedure within 72 hr before onset of bacteremia, prior antibiotics use (cephalosporins, aminoglycosides, and metronidazole) (all $p < 0.05$). For CIP resistance, the significantly associated factors were; post-surgical state, indwelling urinary catheter, invasive procedure within 72 hr before onset of bacteremia, prior use of antibiotics (cephalosporins, aminoglycosides, fluoroquinolones, and

metronidazole) (all $p < 0.05$). However, neutropenia was more frequent in patients with ESC-susceptible *K. pneumoniae* bacteremia than in those infected with ESC-resistant isolates, and also more frequent in those with CIP-susceptible *K. pneumoniae* bacteremia.

By multivariate logistic regression analysis, the significant independent risk factors associated with ESC resistance were invasive procedure before onset of bacteremia, prior use of metronidazole, indwelling urinary catheter, and prior use of cephalosporins. Also, the significant independent risk factors for CIP resistance were invasive procedure before onset of bacteremia, prior use of fluoroquinolones, prior use of metronidazole, post-surgical state, and indwelling urinary catheter.

DISCUSSION

In the current study we present one of the largest recent studies of both community and nosocomial bloodstream infections caused by *K. pneumoniae*. In this study of 377 episodes of bloodstream infection, we found an overall 30-day mortality rate of 24%. Our study examines both community-acquired and nosocomial bloodstream infections, allowing us to estimate the proportion of bloodstream infection mortality that is associated with nosocomial versus community-acquired infections.

We found that 66% of the crude mortality occurred among patients with nosocomial bloodstream infection. In addition, hospital acquisition (nosocomial status) of infection was strongly associated with mortality in our multivariate analysis, even after adjustments were made for underlying illness and other confounding variables.

Neoplastic diseases, such as hematologic malignancy and solid tumor, were the most commonly associated condition in patients with nosocomial *K. pneumoniae* bacteremia. Prior antibiotics use, central line catheterization, indwelling urinary catheter, and neutropenia were common in patients with neoplastic diseases. To the contrary, chronic liver disease (35%) was the most commonly associated condition in patients with community-acquired *K. pneumoniae* bacteremia. Diabetes mellitus was more commonly associated condition in patients with community-acquired *K. pneumoniae* bacteremia than in those with nosocomial bacteremia. The association of diabetes mellitus and *K. pneumoniae* liver abscess was reported previously (11, 15-17). Bacteremic *K. pneumoniae* liver abscess occurred almost exclusively in patients with community-acquired infection, consistent with a growing number of reports from Asia describing this distinctive type of infection (10, 15-17). In our study, 21 patients with liver abscess were identified among 191 patients with community-acquired *K. pneumoniae* bacteremia. Among these, 8 cases were identified to have disseminated infection with metastatic infection. Metastatic infection is a characteristic feature of *K. pneumoniae* liver abscess (15-17).

Pneumoniae carried a significantly poorer prognosis than urinary tract infection, a finding that is in agreement with the results of other studies (1, 5, 18). In our study, peritonitis and unknown primary site of infection were also found to be associated with higher mortality. Not surprisingly, increasing severity of illness at the onset of bacteremia, septic shock, and inappropriate definitive antimicrobial therapy were also associated with increased mortality. These results suggest that when *K. pneumoniae* bacteremia is suspected, the most significant prognostic variables are the primary site of infection (i.e., pneumonia, peritonitis, or unknown) and the severity of the underlying illness (i.e., higher APACHE II score or septic shock). Also, as previously reported in our other study (19), the adequacy of antimicrobial therapy was an important determinant of survival.

Nosocomial isolates were significantly more resistant to the antimicrobial agents that were tested, except for imipenem, when compared with the community-acquired isolates. More than 30% of the nosocomial isolates were resistant to ESC, which raises a concern over an increasing prevalence of ESBL-producing *K. pneumoniae*, particularly in hospitals. We found that the recent use of cephalosporins appeared to be a risk factor for ESC resistance in *K. pneumoniae* bacteremia (20). The ESBL-producing *K. pneumoniae* infections are a risk factor associated with treatment failure (21, 22). Therefore, aggressive infection control and restrictions on the use of ESC should be implemented.

We noted that an invasive procedure, an indwelling urinary catheter, and post-surgical state were risk factors for infection caused by antimicrobial-resistant strains (20). This finding has important implications for nosocomial infection control, as antibiotic-resistant strains in a hospital environment pose a serious risk during the invasive procedures. As suggested by Lautenbach et al., efforts should emphasize limiting contact transmission of resistant isolates as well as controlling antibiotic use (23). Neutropenic patients were significantly less likely to have bacteremic with an ESC-resistant strain than with an ESC-susceptible strain. As previously reported by Paterson et al., this may be noteworthy because neutropenic patients are usually subjected to enhanced infection control measures (5).

We limited our analysis of antibiotic use to 30 days prior to bacteremia and were thus unable to access possible associations between antimicrobial resistance and more remote antibiotic use. Another potential limitation was that molecular epidemiologic analysis was not performed. However, there were no evidences of clonal spread of the resistant organisms, based on the epidemiological findings and the antimicrobial susceptibility patterns of the isolates (data not shown).

As this study was of the retrospective nature, the possibility of the limitation in precluding accurate comparisons should be borne in mind. The data were limited to the hospital record. Although the information concerning the in-hospital antibiotic use was available from the medical record, the record of the use of antibiotic at the outside hospital may not be accu-

rate. Finally, our study was conducted in a large tertiary care medical center, and thus many of our patients had serious underlying illness, including neoplastic diseases and chronic liver diseases. Also, it is noteworthy that 35% of our patients with community-acquired bacteremia had chronic liver diseases, reflecting the high prevalence of chronic hepatitis B virus infection among the general population in Korea (24). Thus the results regarding underlying illness of community vs. nosocomial infections may not be applicable to other institutions.

In conclusions, neoplastic diseases were the most commonly associated conditions in patients with nosocomial *K. pneumoniae* bacteremia, whereas diabetes mellitus and chronic liver disease were the most commonly associated conditions in patients with community-acquired bacteremia. Bacteremic *K. pneumoniae* liver abscess occurred almost exclusively in patients with community-acquired infection. The mortality rate of nosocomial infections was twice higher than that of community-acquired infections. Of all community-acquired and nosocomial isolates, 3.7% and 33.3%, respectively, were ESC-resistant and 4.2% and 21%, respectively, were CIP-resistant. In nosocomial infections, prior uses of ESC and CIP were found to be independent risk factors for ESC and CIP resistance, respectively. An invasive procedure, an indwelling urinary catheter, and post-surgical state were also found to be risk factors for infection.

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