KJIM

Changing trends in clinical characteristics and antibiotic susceptibility of *Klebsiella pneumoniae* bacteremia

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Background/Aims: *Klebsiella pneumoniae* is second most common organism of gram-negative bacteremia in Korea and one of the most common cause of urinary tract infection, and intra-abdominal infection.

Methods: We compared clinical and microbiological characteristics about *K. pneumoniae* bacteremia in a tertiary hospital between 10 years. Group A is who had *K. pneumoniae* bacteremia at least one time from January 2004 to December 2005. Group B is from January 2012 to December 2013. We also analyzed antibiotic resistance, clinical manifestation of the *K. pneumoniae* bacteremia divided into community-acquired infections, healthcare associated infections, and nosocomial infections.

Results: The resistance for ampicillin, aztreonam, cefazolin, and cefotaxime significantly increased compared to 10 years ago. Extended spectrum β-lactamase positivity surged from 4.3% to 19.6%. Ten years ago, 1st, 2nd cephalosporin, and aminoglycoside were used more as empirical antibiotics. But these days, empirical antibiotics were broad spectrum such as 3rd and 4th cephalosporin. In treatment outcome, acute kidney injury decreased from 47.5% to 28.7%, and mortality decreased from 48.9% to 33.2%. In community-acquired infections, there was similar in antimicrobial resistance and mortality. In healthcare-associated and nosocomial infections, there was significantly increasing in antibiotic resistance, decreasing in mortality, and acute kidney injury.

Conclusions: In community-acquired infections, broader antibiotics were more used than 10 years ago despite of similar antimicrobial resistance. When *K. pneumoniae* bacteremia is suspected, we recommend to use the narrow spectrum antibiotics as initial therapy if there are no healthcare-associated risk factors, because the antibiotic resistance is similar to 10 years ago in community-acquired infections.

Keywords: Klebsiella pneumoniae; Bacteremia; Drug resistance

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INTRODUCTION

Klebsiella pneumoniae is a gram-negative rod-shaped bacteria that can cause urinary tract infection, pneumonia, and intra-abdominal infection. *K. pneumoniae* is the main cause of hepatobiliary infection in community-acquired infections and urinary tract infection, pneumonia in healthcare-associated infections and nosocomial

infections [1,2].

K. pneumoniae is the second most common gram-negative bacteria, following to *Escherichia coli*, and one of the most important bacteria of mortality and morbidity. It has been the most common cause of liver abscess in East Asia since the 1990s. The association of *K. pneumoniae* and liver abscess in Korea has been known since the 1990s [1].

Recently, antimicrobial resistance of gram-negative bacteria has been gradually increased worldwide [3]. According to a report of South Korea, the prevalence of *K. pneumoniae* which resistant to ciprofloxacin was increased from 17.1% in 2006 to 26.5% in 2011, and the proportion of multidrug-resistant *K. pneumoniae* producing extended spectrum β-lactamase (ESBL) increased from 13.6% in 2006 to 2007 to 28.5% in 2011 [4].

The aim of this study is to find out the trends of *K. pneumoniae* bacteremia during the last 10-year period. These study groups were divided into two groups as 2004 to 2005 and 2012 to 2013, and analyzed differences about focuses of bacteremia, antibiotic resistance, empirical antibiotics, adequacies, and treatment responses. We also analyzed separately two groups for community-acquired infection and healthcare-associated infection/nosocomial infection.

METHODS

Study subjects

Patients who visited Keimyung University Dongsan Medical Center and had *K. pneumoniae* bacteremia were divided into two groups, as group A was between January 2004 and December 2005 and group B was between January 2012 and December 2013, respectively. Patients under 18 years old or polymicrobial bacteremia were excluded. Patients who were transferred to other hospitals during treatment were also excluded. There were the 169 *K. pneumoniae* bacteremia cases in group A; eight patients were excluded for the polymicrobial bacteremia; nine children were excluded; and 12 patients were excluded for transferred to other hospitals. There were the 230 *K. pneumoniae* bacteremia cases in group B; four patients were excluded for the polymicrobial bacteremia; six children were excluded; and 16 patients were excluded for transferred to other hospitals (Fig. 1). One hundred and forty patients in group A and 204 patients in group B were retrospectively investigated.

Study item

Medical records, including underlying diseases, previous antibiotics, previous admissions of intensive care unit (ICU), antibiotic resistance rates, clinical features, and treatments, were retrospectively analyzed. Age and sex in two groups were compared; antibiotics resistance rates and empirical antibiotics were compared and analyzed by each group. The focus of infection was determined according to physician's diagnosis based on patient symptoms, physical examination findings, and detections of *K. pneumoniae* in other samples.

Community-acquired infections were defined as those in which symptoms occurred within 48 hours after visiting the hospital. Nosocomial infections were defined as those in which symptoms occurred 48 hours after hos-
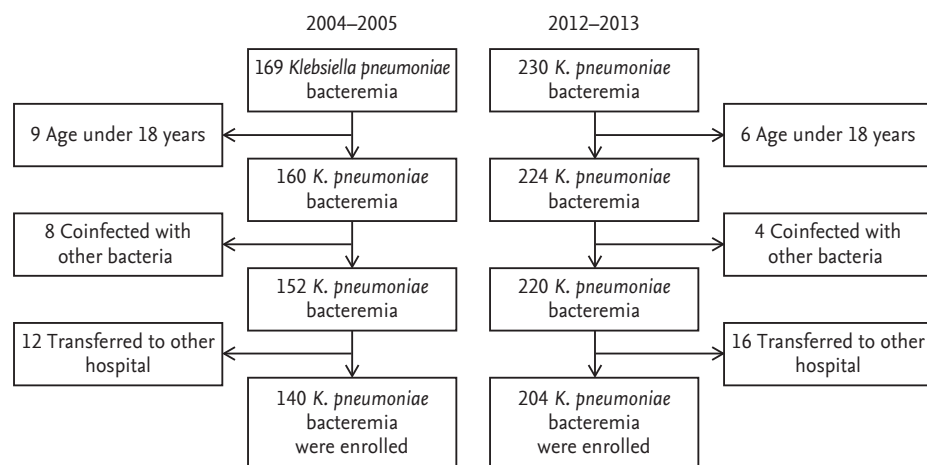

Figure 1. Enrollment of patients in the study.

Hyun M, et al. Trends of *Klebsiella pneumoniae* bacteremia

KJIM

pital admission. Patients with community-acquired infections who had healthcare-associated risk factors were categorized as healthcare-associated infections. Healthcare-associated risk factors were hospitalization within 90 days, received dialysis, taken intravenous medication in outpatient clinics, or resided in long-term care facilities.

Pitt bacteremia score was calculated based on temperature (35.1°C to 36°C or 39.0°C to 39.9°C, 1 point; ≤ 35°C or ≥ 40°C, 2 points), blood pressure (hypotension, 2 points), mental status (disorientation, 1 point; stupor, 2 points; coma, 4 points), respiratory status (mechanical ventilation, 2 points), and cardiac status (cardiac arrest, 4 points). The worst reading was recorded on the day the first positive blood culture was obtained or the day before for nosocomial bloodstream infections.

Treatment outcome was evaluated after 72 hours of empirical antibiotics, based on infection-related mortality, admission of ICU, acute kidney injury, mechanical ventilation, recurrence of bacteremia, and laboratory tests. Treatment outcome was classified as complete response, partial response, and treatment failure. Complete response was defined as both laboratory findings and clinical states were improved. Partial response was defined as either laboratory findings or clinical states was improved. Treatment failure was defined as both were worsened and infection-related death. If patient died of *K. pneumoniae* bacteremia or complication of infection, we defined this situation as infection-related death. Acute kidney injury was defined as increase in serum creatinine by > 0.3 mg/dL within 48 hours; or increase in serum creatinine to > 1.5 times baseline, which have occurred within the prior 7 days; or urine volume < 0.5 mL/kg/hr for 6 hours.

Statistics

Statistical analysis was performed using SPSS version 21.0 (IBM Co., Armonk, NY, USA) and MedCalc for Windows version 16.4.1. (MedCalc Software, Ostend, Belgium). Binary data were compared using the chi-square test and continuous scaled analysis were compared using Student t test. The data were confirmed to have a normal distribution; mean values were used as representative values. Statistical significance was defined as p values less than 0.05 and Kaplan-Meier survival analysis was used to test for correlations between clinical features, mortality, and hazard ratio. This study was

approved by the Ethical Committees and Institutional Review Boards of Keimyung University Dongsan Medical Center, Daegu, Korea (IRB No. 2014-02-008). IRB approved a waiver of the requirements to obtain informed consent for this study.

RESULTS

Basic characteristics of study group

In group A, 140 patients were included; 86 (61.4%) were males; and the mean age was 68.5 years. In group B, 204 patients were included; 116 (56.9%) were males; and the mean age was 68.0 years. There were no statistically significant differences in gender or age between two groups.

Analysis of underlying diseases revealed that group B had significantly higher incidence of cardiovascular and cerebrovascular disease than group A. Incidence rates of community-acquired, healthcare-associated infections and nosocomial infections were each 53%, 20.1%, and 26.6% in group A, and 45.6%, 27.5%, and 27% in group B, respectively (Table 1). Mean Pitt score was 4.81 in group A and 2.93 in group B and that was statistically significant. In community-acquired infection, Pitt score was 4.15 in group A and 3.41 in group B. In healthcare-associated infection/nosocomial infections, Pitt score was 5.43 in group A and 2.53 in group B.

In community-acquired infections, hepatobiliary infections were most prevalent, 43.2% and 48.4% each in group A and B. In nosocomial infections, pneumonia was the most prevalent with rates of 16.7% and 24.3% each in group A and B, followed by hepatobiliary infections, with rates of 21.2% and 17.1% each in group A and B, but this difference between group A and B was not statistically significant.

Comparison of antibiotic resistance, empirical antibiotics, and antibiotic adequacy

Previous antibiotics within 1 month had increased significantly compared to 10 years before (7.9% vs. 27.1%, p = 0.001); however, the types of antibiotics did not differ significantly.

Antibiotic resistance had increased between group A and B significantly. Rates of ESBL-producing bacteria, and resistance to aztreonam, cefotaxime, and cefepime

Table 1. Comparison of *Klebsiella pneumoniae* bacteremia according to sex and category of infection

Variable	Group A[a] (n = 140)	Group B[b] (n = 204)	*p* value
Age, yr	68.5 ± 11	68 ± 14	0.308
Sex			0.436
Male	86 (61.4)	116 (56.9)	
Female	54 (38.6)	88 (43.1)	
Category of infection			0.155
Community-acquired	75 (53.2)	93 (45.6)	
Healthcare-associated	25 (20.1)	56 (27.5)	
Nosocomial	37 (26.6)	55 (27.0)	
Comorbidity			
Solid tumor	43 (30.7)	73 (36.1)	0.353
Hematologic malignancy	6 (4.3)	15 (7.4)	0.261
Cardiovascular disease	34 (24.3)	96 (47.5)	0.001
Neurovascular disease	15 (10.8)	40 (19.8)	0.035
Diabetes mellitus	48 (34.3)	75 (37.1)	0.647
Origin of infection			
Hepatobiliary infection	46 (32.9)	64 (31.4)	0.814
Urinary tract infection	24 (17.1)	35 (17.2)	1.000
Respiratory infection	21 (15.0)	34 (16.7)	0.765
Intra-abdominal infection	14 (10.0)	20 (9.8)	1.000
Surgical site infection	3 (2.1)	3 (1.5)	0.691
Catheter related infection	1 (0.7)	8 (3.9)	0.089
CNS infection	1 (0.7)	1 (0.5)	1.000
Bone/joint infection	0	2 (1.0)	0.516

Values are presented as mean ± SD or number (%).
CNS, central nervous system.
[a]Group A, 2004–2005. [b]Group B, 2012–2013.

increased significantly over time (Table 2). Antibiotic resistance was analyzed separately for community-acquired, and healthcare-associated infections/nosocomial infections. It showed no differences in community-acquired infections between group A and B. However, antibiotic resistance for healthcare-associated infections/nosocomial infections increased significantly compared to 10 years previously (Table 3).

Ten years before, second-generation cephalosporin and aminoglycoside were most commonly used as empirical antibiotics. Recently, broad-spectrum antibiotics such as fourth-generation cephalosporin, carbapenem, and vancomycin were commonly used as empirical antibiotics and it increased significantly (Fig. 2). In analysis of empirical antibiotics, broad-spectrum antibiotics had increased, such as fourth-generation cephalosporin and

carbapenem, especially in community-acquired infections (Table 4).

Comparison of adequacy of empirical antibiotics according to antibiotic susceptibility showed that use of broad-spectrum antibiotics compared with antimicrobial resistance increased significantly compared to past (5.0% vs. 28.5%, *p* = 0.001).

Comparison of treatment outcomes

Assessment of treatment outcome after 72 hours of management revealed improvement in group B. Complete response was in 3.6% and 25.2% of group A and group B patients, partial response in 59.7% and 40.6%, and treatment failure in 31.6% and 34.2%. Rates of acute kidney injury, mechanical ventilation, and 30-day mortality were decreased in group B, significantly (Table 5).

Hyun M, et al. Trends of *Klebsiella pneumoniae* bacteremia

KJIM

Table 2. Comparison of antibiotic resistance

Variable	Group A[a]	Group B[b]	*p* value
Amikacin	10 (7.1)	10 (4.9)	0.483
Amoxicillin/clavulanate	16 (11.4)	18 (8.8)	0.603
Ampicillin	135 (96.4)	204 (100)	0.025
Aztreonam	13 (9.3)	41 (20.1)	0.013
Cefazolin	14 (10.0)	43 (21.1)	0.013
Cefepime	0	39 (19.1)	0.001
Cefotaxime	10 (7.1)	41 (20.1)	0.001
Cefoxitin	7 (5.0)	14 (6.9)	0.729
Ciprofloxacin	9 (6.4)	24 (11.8)	0.113
Gentamicin	13 (9.3)	27 (13.2)	0.503
Piperacillin/tazobactam	10 (7.2)	20 (9.8)	0.344
Tigecycline	8 (5.7)	9 (4.4)	0.706
TMP/SMX	12 (8.6)	26 (12.7)	0.237
ESBL positivity	6 (4.3)	40 (19.6)	0.001

Values are presented as number (%).
TMP, trimethoprim; SMX sulfamethoxazole; ESBL, extended-spectrum β-lactam.
[a]Group A, 2004–2005. [b]Group B, 2012–2013.

In healthcare-associated infection/nosocomial infection, overall treatment outcome has improved. Specifically, complete response increased in group B compared to group A, and the treatment failure, 30-day mortality, and mechanical ventilation was decreased in group B compared to group A. They were also significantly reduced (Table 6).

In community-acquired infection, treatment outcome was improved overall. Complete response was observed in 25% of patients in group B compared to 5.5% in group A, while treatment failure increased to 31.5% in group B from 30.1% in group A. Differences between the occurrence rates of two groups of acute kidney injury, mechanical ventilation, and 30-day mortality were not statistically significant (Table 6).

Kaplan-Meier survival analysis was performed to recognize the difference in survival rates between group A and B (Fig. 3). In group B, survival rates increased significantly compared to group A (hazard ratio, 1.53; 95% CI, 1.08 to 2.18; *p* = 0.011).

Table 3. Comparison of antibiotic resistance in community-acquired infection and healthcare associated infection/nosocomial infection between two groups

Variable	Community-acquired infection			Healthcare-associated/nosocomial infection		
	Group A[a] (n = 74)	Group B[b] (n = 93)	*p* value	Group A[a] (n = 66)	Group B[b] (n = 111)	*p* value
Amikacin	2 (2.7)	1 (1.1)	0.585	8 (12.1)	9 (8.1)	0.433
Amoxicillin/clavulanate	5 (6.8)	1 (1.1)	0.033	11 (16.7)	17 (15.3)	0.851
Ampicillin	70 (94.6)	93 (100)	0.076	65 (98.5)	111 (100)	0.373
Aztreonam	5 (6.8)	5 (5.4)	0.752	8 (12.1)	36 (32.4)	0.005
Cefazolin	5 (6.8)	6 (6.5)	1.000	9 (13.6)	37 (33.3)	0.008
Cefepime	0	5 (5.4)	0.067	0	34 (30.6)	0.001
Cefotaxime	3 (4.1)	5 (5.4)	0.495	7 (10.6)	36 (32.4)	0.002
Cefoxitin	3 (4.1)	2 (2.2)	0.406	4 (6.1)	12 (10.8)	0.557
Ceftazidime	3 (4.1)	5 (5.4)	0.495	5 (7.6)	35 (31.5)	0.001
Ciprofloxacin	2 (2.7)	2 (2.2)	1.000	7 (10.6)	22 (19.8)	0.135
Gentamicin	5 (6.8)	2 (2.2)	0.174	8 (12.1)	25 (22.5)	0.221
Piperacillin/tazobactam	2 (2.7)	2 (2.2)	0.970	8 (12.1)	18 (16.2)	0.165
Tigecycline	4 (5.4)	1 (1.1)	0.259	4 (6.1)	8 (7.2)	0.520
TMP/SMX	3 (4.1)	3 (3.2)	1.000	9 (13.6)	23 (20.7)	0.224
ESBL positivity	2 (2.7)	5 (5.4)	0.465	4 (6.1)	35 (31.5)	0.001

Values are presented as number (%).
TMP, trimethoprim; SMX, sulfamethoxazole; ESBL, extended-spectrum β-lactam.
[a]Group A, 2004–2005. [b]Group B, 2012–2013.

DISCUSSION

There have been reports of community-acquired highly pathogenic strains of *K. pneumoniae* infections in South Korea. Hypervirulent K1 and K2 serotypes of *K. pneumoniae* were first identified as important causes of liver abscess in community-acquired infections since the 1990s [5]. But, investigations of overall *K. pneumoniae* bacteremia are insufficient in South Korea. Therefore, this study was aim to analyze focuses of *K. pneumoniae* bacteremia, antimicrobial resistance, clinical characteristics, and risk factors among patients who visited a tertiary medical center between 2003 to 2004 (group A) and 2012 to 2013 (group B), retrospectively.

In this study, liver abscess and other hepatobiliary infection, urinary tract infection, and pneumonia were frequent cause of *K. pneumoniae* bacteremia, but not statistically significant. Liver abscess was most prevalent,

Figure 2. Comparison of empirical antibiotics.

followed by urinary tract infections in community-acquired infections, while pneumonia and urinary tract infections were most prevalent in healthcare-associated infections and nosocomial infections. These findings are in accordance with other investigations conducted in South Korea as well as overseas. Other South Korean studies have reported that intra-abdominal infections and urinary tract infections to be the most prevalent cause of community-acquired *K. pneumoniae* bacteremia during the same period; intra-abdominal infection, pneumonia, and urinary tract infection were the most prevalent causes of nosocomial *K. pneumoniae* bacteremia [6,7]. In a study conducted overseas, liver abscess was prevalent in community-acquired infections, whereas pneumonia and catheter-associated infection were common in nosocomial infections [8].

Worldwide, the antibiotic resistance rates of gram-negative bacteria, including *K. pneumoniae*, are gradually increasing [4]. This study found that recent antibiotic resistance of *K. pneumoniae* in healthcare-associated infections and nosocomial infections was significantly increased compared to 10 years before. In subgroup analysis, antibiotic resistance was similar in community-acquired infection, and the recent increased antibiotic resistance was due to increased resistance in healthcare-associated infections and nosocomial infections. We found that antibiotics susceptibility of community-acquired *K. pneumoniae* bacteremia has been maintained for 10 years.

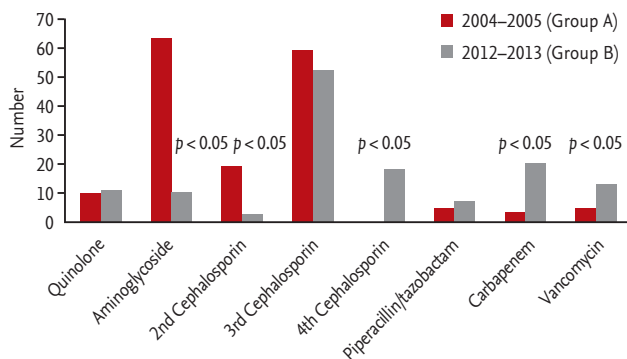A study in South Korea showed that the rates of resistance to third-generation cephalosporin in community-

Table 4. Empirical antibiotics in community-acquired infection and healthcare associated infection/nosocomial infection between two groups

Variable	Community-acquired infection			Healthcare-associated/nosocomial infection		
	Group A[a] (n = 74)	Group B[b] (n = 93)	*p* value	Group A[a] (n = 66)	Group B[b] (n = 111)	*p* value
1st, 2nd cephalosporin	16 (21.9)	1 (1.1)	0.001	10 (15.2)	3 (2.7)	0.005
3rd cephalosporin	43 (58.9)	59 (64.1)	0.522	39 (59.1)	46 (41.8)	0.030
4th cephalosporin	0	14 (15.2)	0.001	0	22 (20.2)	0.001
Aminoglycoside	48 (65.8)	5 (5.4)	0.001	40 (60.6)	15 (13.6)	0.001
Quinolone	9 (12.3)	5 (5.4)	0.160	4 (6.1)	16 (14.5)	0.139
Piperacillin/tazobactam	2 (2.7)	2 (2.2)	1.000	4 (6.1)	12 (10.9)	0.417
Imipenem/meropenem	0	17 (18.5)	0.001	4 (6.1)	23 (20.9)	0.009

Values are presented as number (%).
[a]Group A, 2004–2005. [b]Group B, 2012–2013.

Table 5. Comparison of treatment response

Variable	Group A[a] (n = 140)	Group B[b] (n = 204)	p value
Response after 72 hr			0.001
Complete response	5 (3.6)	51 (25.2)	
Partial response	83 (59.7)	82 (40.6)	
Failure	51 (31.6)	69 (34.2)	
ICU care	54 (38.8)	65 (32.2)	0.206
AKI	66 (47.5)	58 (28.7)	0.001
Mechanical ventilation	41 (29.5)	34 (16.8)	0.008
30-Day mortality	68 (48.9)	66 (33.2)	0.005

Values are presented as number (%).
ICU, intensive care unit; AKI, acute kidney injury.
[a]Group A, 2004–2005. [b]Group B, 2012–2013.

acquired *E. coli* or *K. pneumoniae* infections increased from 6.1% in 2003 to 2008 to 10.6% in 2009. In ICU patients with gram-negative bacteremia, ciprofloxacin was the most adequate antibiotic in 1999 [9]. In 2005, however, imipenem and tobramycin were reported adequate antibiotics rather than ciprofloxacin [10]. This result shows antibiotic resistance of gram-negative bacteria in ICU has been increased.

This study compared community-acquired infections and healthcare-associated infections/nosocomial infections during the same period, and found that healthcare-associated infections/nosocomial infections had higher mortality, although the difference was reduced compared to 10 years previously.

Table 6. Comparison of treatment response in community-acquired infection and healthcare associated infection/nosocomial infection between two groups

Variable	Community-acquired infection			Healthcare-associated/nosocomial infection		
	Group A[a] (n = 74)	Group B[b] (n = 93)	p value	Group A[a] (n = 66)	Group B[b] (n = 111)	p value
Response after 72 hr			0.002			0.001
Complete response	4 (5.5)	23 (25.0)		1 (1.5)	28 (25.5)	
Partial response	47 (64.4)	40 (43.5)		36 (54.5)	42 (38.1)	
Failure	22 (30.1)	29 (31.5)		29 (43.9)	40 (36.4)	
ICU care	27 (37.0)	33 (35.9)	1.000	27 (40.9)	32 (29.1)	0.138
AKI	26 (35.6)	23 (30.4)	0.508	40 (60.6)	30 (27.3)	0.001
Mechanical ventilation	22 (30.1)	18 (19.6)	0.144	19 (28.8)	16 (14.5)	0.031
30-Day mortality	28 (38.4)	25 (28.1)	0.181	40 (60.6)	41 (37.3)	0.003

Values are presented as number (%).
ICU, intensive care unit; AKI, acute kidney injury.
[a]Group A, 2004–2005. [b]Group B, 2012–2013.
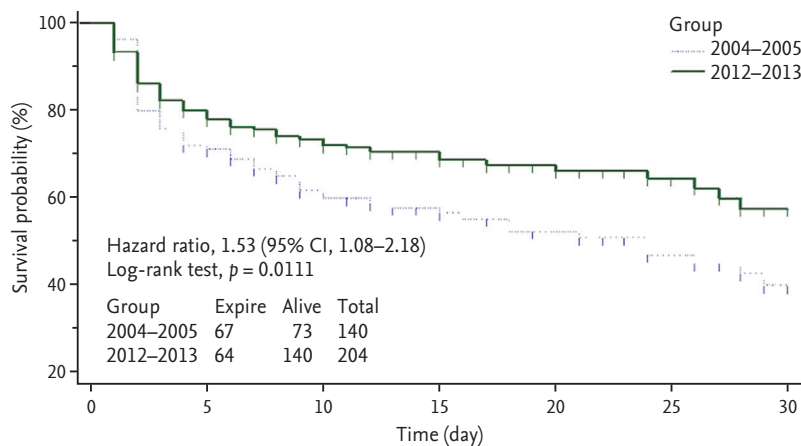
Figure 3. Comparison of cumulative survival between two groups.

A study by Kang et al. [1] reported that nosocomial *K. pneumoniae* infections had a 32.3% of 30-day mortality, significantly higher than 16.2% for community-acquired infections. Factors influencing on mortality included inadequate empirical antibiotics, inadequate susceptible antibiotics, admission to ICU, septic shock, neutropenia, and use of immunosuppressants [11].

In this study, treatment outcome after 72 hours showed better and 30-day mortality was reduced compared to 10 years previously. Pitt score was decreased compared to 10 years previously, and it was statistically significant. Sepsis treatment guidelines are continuously changed; recent guideline suggested that providing sufficient fluids within the first 6 hours and prompt use of vasopressors in order to maintain central venous pressure of 8 to12 mmHg, mean arterial pressure of 60 mmHg, and hourly urine volume of 0.5 mL/kg to achieve early treatment in patients with suspected sepsis [12]. This practice may have improved treatment response within the first 72 hours and reduced acute kidney injury due to infection or ischemia which sometimes accompanies sepsis [9].

Morbidity and mortality of *K. pneumoniae* bacteremia are gradually increasing, according to a South Korean study that analyzed 147 patients with gram-negative bacteremia. *K. pneumoniae* bacteremia was 5.4% of gram-negative bacteremia, and its mortality was 37.5%, higher mortality than other gram-negative bacterial infections [3,9,13].

This study revealed that in community-acquired infection, Pitt score was decreased from 4.15 to 3.41 between 10 years and antimicrobial resistance was similar, but use of broad-spectrum antibiotics increased from 4.1% to 35.5%. According to these results, there was no change of antimicrobial resistance in community-acquired infections between two groups. It means that if *K. pneumoniae* bacteremia is suspicious and healthcare-associated infection is excluded, excessive use of broad-spectrum antibiotics in the early stage of disease may be reduced. Excessive use of broad-spectrum antibiotics makes more antibiotic resistance [14]. Therefore, adequate use of empirical antibiotics in community-acquired infection will help prevent antimicrobial resistance and reduce medical costs from inadequate use of expensive broad-spectrum antibiotics. In group A, 12% were inappropriate for initial empirical antibiotic and in group B, 15% were in appropriate. That was not statistically significant. Among cases of inappropriate

empirical antibiotics, 5% was changed to definite antibiotics in group A, and 37.3% of group B was changed to definite antibiotics after identifying antibiotic susceptibility results. The change of the appropriate antibiotic might have influenced the mortality. However, antibiotic resistance dramatically increased among healthcare-associated infections and nosocomial infections. Use of broad-spectrum antibiotics in early stage may be considered for patients with risk factors of nosocomial or healthcare-associated infections.

This study was conducted in order to announce that broad-spectrum antibiotics were increased steadily despite of similar antimicrobial resistance in community-acquired *K. pneumoniae* bacteremia compared to 10 years before. Therefore, we agitate use of narrow spectrum antibiotics, if the patient has community-acquired *Klebsiella* bacteremia and doesn't have risk factors of healthcare-associated bacterial infection. We intent to announce in this study when community-acquired *K. pneumoniae* bacteremia is suspected, like liver abscess or urinary tract infection, clinicians may need to reduce the use of broad spectrum antibiotics as initial treatment.

There are several potential limitations in this study. Firstly, this study was retrospective, conducted in a tertiary hospital, and relied on microbiological culture results, which may introduce bias in the data interpretation. Secondly, we should acknowledge that the patients included in this study were in a tertiary hospital and might be more severe than primary medical center. Despite of these limitations, we discovered the trends about antimicrobial resistance and pattern of antimicrobial prescription of *K. pneumoniae* bacteremia over 10 years.

KEY MESSAGE

1. This study showed that the overall antibiotic resistance rate of *Klebsiella pneumoniae* increased significantly compared to 10 years previously.
2. In community-acquired infections, the antibiotic resistance was not increased and Pitt bacteremia score was decreased than 10 years previously.
3. For both community-acquired and healthcare-associated infections, broad-spectrum antibiotics are more commonly used for empirical

Hyun M, et al. Trends of *Klebsiella pneumoniae* bacteremia

KJIM

treatment compared to 10 years previously.

4. Unnecessary use of broad spectrum antibiotics can be reduced if *K. pneumoniae* bacteremia is suspicious and there are no healthcare risk factors, because antibiotic resistance in community-acquired *K. pneumoniae* bacteremia was not increased.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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