Changes in Bacterial Species and Antibiotic Sensitivity in Intensive Care Unit: Acquired Urinary Tract Infection during 10 Years Interval (2001-2011)

Byung Il Yoon,[1] Hyo Sin Kim,[2] Sung Dae Kim,[3] Kang Jun Cho,[2] Sun Wook Kim,[4] U-Syn Ha,[4] Yong-Hyun Cho,[4] Dong Wan Sohn[4]

[1] Department of Urology, International St. Mary's Hospital, Incheon, Korea.
[2] Department of Urology, Bucheon St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Bucheon, Korea.
[3] Department of Urology, School of Medicine, Jeju National University, Jeju, Korea.
[4] Department of Urology, Yeouido St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea.

Corresponding Author:

Department of Urology, Yeouido St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea.

Tel: +82 2 3779 1038
Fax: +82 2 761 1626
E-mail address: uroking@naver.com

Received September, 2012
Accepted December, 2013

Purpose: Patients in the intensive care unit (ICU) are usually at greater risk for acquiring urinary tract infections (UTIs). Few studies have focused on UTIs specifically acquired within the ICU. We studied the change in bacterial species causing UTIs in ICU admitted patients in 2001 and 2011.

Materials and Methods: We reviewed the medical records of a total of 2,890 ICU patients who had undergone urine culture in 2001 and 2011 at the Yeouido and Bucheon St. Mary's hospitals. Changes in causative organisms and their antibiotic sensitivity between the years 2001 and 2011 were analyzed.

Results: Escherichia coli (E. coli) was the most common organism in ICU-acquired UTIs in 2001 and 2011 in our study. The pathogens that significantly increased in 2011 compared to 2001 were Pseudomonas, and Klebsiella species ($P < .05$). In 2011gram-negative organisms showed relatively higher sensitivities to amikacin, imipenem, and tazocin (72.0%, 77.5% and 76.1%, respectively), whereas they showed relatively lower sensitivities to third-generation cephalosporins and ciprofloxacin (55.2% and 45.0%, respectively). In 2011gram-positive organisms showed high sensitivities to teicoplanin and vancomycin (91.1% and 87.9%, respectively), whereas they showed low sensitivities to ampicillin and ciprofloxacin (24.1% and 25.5%, respectively). The antibiotic resistance rate of Pseudomonas species was nearly doubles that of E. coli.

Conclusion: Infections caused by Pseudomonas and Klebsiella species were found to have increased significantly in 2011. Pseudomonas species had a significantly lower susceptibility to antibiotic sensitivity than other identified organisms.

Keywords: bacterial infections; drug resistance; intensive care units; microbial sensitivity tests; retrospective studies.

INTRODUCTION

Patients admitted to intensive care unit (ICU) are prone to various infections i.e. lung, urinary tract, skin, oral mucosal and etc. A huge number of infections are device-associated health-care-associated infection (DA-HAI), or nosocomial infections.[1] As is known to all, due to the specificity of pathogens and high drug resistance, nosocomial infection is often difficult to control, and associates with poor outcome.[2]

Urinary tract infections (UTIs) are one of the most common types of nosocomial infections encountered in the inpatient settings including ICU. Amongst patients admitted to ICU, studies have revealed the incidence of nosocomial UTIs to range from 9% to 29%.[3,4] The risk of patients acquiring a UTIs in an ICU is approximately 2.5-fold higher than that of patients in a general hospital ward. Complicated nosocomial UTIs may lead to urosepsis, and increase patient morbidity and mortality.[5]

The primary cause for nosocomial UTIs is catheterization of the urinary system. Since most ICU patients are monitored with regard to the amount of intake and output by the Foley catheter, they are easily exposed to the risk of infection due to its indwelling characteristic. To date, many studies have been conducted to examine the causative bacteria for UTIs among outpatients and hospitalized patients. However, few studies have focused on UTI causative organisms or their sensitivity to antibiotics in ICU patients. In UTI cases, empirical antibiotics should be used until the bacterial culture is confirmed; therefore, it is essential to examine the antibiogram of the causative organism. Sensitivity to antibiotics may vary depending on the hospital and the region. Particularly for patients in the ICU, causative bacteria for UTIs may be different from those isolated from the regular outpatient and general ward patients. Specifically, in ICU patients the sensitivity to antibiotics may be lower compared to other patients.

Based on this information, we comparatively analyzed the major causative bacteria of UTIs and investigated disparity in the sensitivity to antibiotics between isolates from 2001 and 2011 in the ICUs of two medical institutions.

MATERIALS AND METHODS

A retrospective analysis was performed on urine cultures performed in 2001 and 2011 in ICU patients in two hospitals. Four ICUs included in this study: surgical ICU (25 bed), medical ICU (24 bed), neurosurgical ICU (20 beds) and cardiac ICU (16 beds). We defined ICU acquired UTI when urine culture is positive [urine culture with a bacterial count >100,000 colony-forming units (CFU)/mL] within 48 hours or later after admission in ICU.[6] We excluded the patients who showed a positive urine culture within 30 days to minimize the duplication of test results such as reinfections of first UTI. The medical records of patients were reviewed to make a differential diagnosis between asymptomatic bacteriuria and UTI. Dysuria and fever at the time of urine culture testing were considered as symptomatic of UTI. Asymptomatic bacteriuria was excluded from the study.

Urine collection was conducted according to the following methods. The tip of the catheter was cleaned using a boric sponge, and then the urine was collected using a sterilized syringe from patients with an indwelling catheter. From the patients without indwelling catheters, the middle urine was collected after cleaning of the urethral meatus and the perineal region using a boric sponge. If self-voiding was impossible, urine samples were obtained by catheterization. The midstream urine was collected from pediatric patients with the ability of voiding control. In other cases, urine samples were obtained by catheterization. Bacterial identification was conducted with the use of ATB kits (BioMérieux, Mumbai, India). Species identification for yeast was done on VITEK 2 Compact system (BioMérieux, Mumbai, India) as per the manufacturers' instruction. Antimicrobial susceptibility tests were performed using the Kirby-Bauer method. The protocol of the study was approved by a central ethical committee (Catholic Medical Center, The Catholic University of Korea College of Medicine, Seoul, Korea, No. HIRB-00145_2-002) and by the respective local ethical committees.

Statistical Analysis

Sigmastat for Windows (Systat Inc., Chicago, IL, USA) was used for statistical analysis. To make a comparison of the rate of bacterial culture between the two years, a Fisher's exact test was performed. A P value < .05 was considered statistically significant.

RESULTS

The number of ICU patients who underwent urine culture testing was 1,007 in 2001 and 1,883 in 2011, for a total of 2,890 ICU patients who underwent urine culture testing. Of these patients, 208 in 2001 and 256 in 2011 met study criteria and enrolled into the study.

Table 1. Species distribution of urine isolates from patients with urinary tract infections.

Organisms	2001 (%)	2011 (%)	*P*
Escherichia coli	24.5	23.1	.475
Enterococcus	15.5	17.2	.308
Yeast	13.7	15.5	.530
Coagulase negative staphylococcus	7.2	4.2	.176
Pseudomonas	10.5	19.0	.003
Klebsiella	4.2	10.1	.04
Staphylococcus aureus	8.2	4.2	.054
Others*	16.2	6.7	.005
Totals	100.0	100.0	-----

* Enterobacter, Serratia, Stenotrophomonas, Streptococcus, Myroides, Proteus, Providencia, Morganella, Citrobacter, Acinetobacter and Alcaligenes genera.

The male to female ratio was 93:129 in 2001 and 107:120 in 2011 ($P = .689$). The mean ages were 57.4 ± 21.7 years in 2001 and 60.7 ± 24.4 years in 2011 ($P = .854$). In both years, the most common bacterial strain isolated from UTI patients was E. coli (Table 1). In 2001, the causative bacterial species that were cultured included E. coli (24.5%), Enterococcus (15.5%), Pseudomonas (10.5%), Staphylococcus (8.2%), coagulase negative Staphylococcus (CNS) (7.2%) and Klebsiella (4.2%). In 2011, the causative bacteria that were cultured included E. coli (23.1%), Pseudomonas (19.0%), Enterococcus (17.2%), Klebsiella (10.1%), CNS (4.2%), and Staphylococcus (4.2%). For yeast species, Candida and Trichosporon species were identified. Other bacterial strains included, Enterobacter, Serratia, Stenotrophomonas, Streptococcus, Myroides, Proteus, Providencia, Morganella, Citrobacter, Acinetobacter and Alcaligenes. Overall, the proportion of gram-negative bacteria was 35.0% in 2001 and 50.1% in 2011 ($P < .05$) and the proportion of gram-positive bacteria was 30.9% in 2001 and 39.6% in 2011 ($P = .748$). The proportion of yeast was 13.7% in 2001 and 15.5% in 2011. The proportion of Pseudomonas and Klebsiella significantly increased from 2001 to 2011 ($P < .05$). Despite a lack of statistical significance, the proportion of Enterococcus increased from 15.5% to 17.2% and Staphylococcus aureus decreased from 8.2% to 4.2% in 2011 compared to 2001.

In each bacterial strain, antibiotic sensitivity was analyzed (Table 2). Ampicillin showed low sensitivity to gram-negative bacteria (24.5% in 2001 and 23.4% in 2011). Ceftazidime, a third-generation cephalosporin, showed relatively high sensitivity to gram-negative bacteria (33.0% in 2001 and 62.0% in 2011). Of the aminoglycosides in gram-negative bacteria, amikacin (70.2% in 2001 and 72.0% in 2011) showed high sensitivity as compared to gentamicin (60.1% in 2001 and 57.2% in 2011) or tobramycin (54.5% in 2001 and 60.1% in 2011). Quinolones such as ciprofloxacin showed relatively low sensitivity (50.1% in 2001 and 55.2% in 2011) compared to the aminoglycosides in gram-negative bacteria. In addition, the Bactrim (sulfamethoxazole and trimethoprim) showed a low degree of antibiotic sensitivity at 30.2% and 40.1%, respectively.

In a meticulous review of the data, Escherichia coli (E. coli) had a lower degree of antibacterial sensitivity to ampicillin in 2001 and in 2011, but it had a relatively higher degree of antibacterial sensitivity to the third-generation cephalosporin ceftazidime in 2001 and in 2011. In the case of aminoglycosides, amikacin showed a very high antibacterial sensitivity. Ciprofloxacin had a relatively higher degree of antibacterial sensitivity in 2001 and in 2011. Klebsiella had a very low degree of antibacterial sensitivity to ampicillin in 2001 and in 2011. Pseudomonas was found to have almost no sensitivity to cefotaxime and then showed a relatively lower degree of antibacterial sensitivity to ceftazidime, the aminoglycosides, and quinolone at a rate of 30-40%. In particular, there was a low degree of antibacterial sensitivity to imipenem at a rate of 45% in 2011 (Table 3).

According to the results obtained for 2011, Enterococcus had a lower degree of antibacterial sensitivity to ampicillin and ciprofloxacin but had a higher degree of antibacterial sensitivity to tetracycline, teicoplanin, and vancomycin. Staphylococcus had a higher degree of antibacterial sensitivity to

Table 2. Antibiotic sensitivities for gram-stained pathogens in 2001 versus 2011.

Variables		Antibiotic Susceptibility (%)											
	Year	AC	CL	CZ	CT	GM	AK	TM	CF	LF	IP	BT	TZ
Gram (-)	2001	24.5	51.8	33.0		60.1	70.2	54.5	50.1	55.8	90.8	30.2	70.2
	2011	23.4	45.5	62.0	44.0	57.2	72.0	60.1	55.2	82.1	77.5	40.1	76.1
P		.982	.731	< .05		.684	.963	.741	.891	<0.05	< .05	.061	.794
		Antibiotic Susceptibility (%)											
	Year	EM	GM	TC	AC	CL	TP	VM	CF				
Gram (+)	2001	24.5	24.1	60.1	9.2	20.4	85.4	85.7	39.5				
	2011	27.1	10.2	54.2	24.1	19.1	91.1	87.9	25.5				
P		.891	< .05	.641	< .05	.941	.791	.912	< .05				

Keys: AC = ampicillin, CL = cephalothin, CZ = ceftazidime, CT = cefotaxime, GM = gentamicin, AK = amikacin, TM = tobramycin, CF = ciprofloxacin, LF = levofloxacin, IP = imipenem, BT = bactrim, TZ = tazocin, EM = erythromycin, TC = tetracycline, TP = teicoplanin and VM = vancomycin.

teicoplanin and vancomycin in 2001 and in 2011. Some antibiotics were not considered for drug sensitivity testing and thus had no available results. In the tested drugs, sensitivity was shown to change with time (Table 4).

DISCUSSION

The major findings of our study were as follows; E. coli was the most common organism in ICU-acquired UTIs both in 2001 and 2011; Pseudomonas, and Klebsiella species significantly increased in 2011 compared to 2001 and infections with Pseudomonas, the antibiotics resistance rates were higher than that of other bacterial strains. UTI is one of the most common infectious diseases, only second to respiratory infections in clinical practice of internal medicine. Despite the rapidly updated treatment modalities for UTI, some patients with refractory UTIs and complicated UTIs are difficult to treat.[7] A nosocomial UTI is one of the most common types of infections and accounts for the highest incidence of total nosocomial infections. According to a survey that was conducted to examine disease status in 1996, the incidence of UTIs constituted 30.3% of total nosocomial infection cases.[8] According to clinical guidelines proposed by the European Association of Urology (EAU) in 2006, cases in which a UTI was acquired in a hospital setting were established as one of the indicators associated with complex UTIs[9] because patients who have been hospitalized were typically older in age and had complicating chronic diseases such as diabetes mellitus or hypertension. In addition, they had a higher frequency of exposure to other infectious diseases. These characteristics are more prevalently seen in ICU patients in particular.

Most cases of ICU-acquired UTIs occur as the result of single bacterial strain infections. Complex-type infections due to more than two bacterial strains have been reported to occur at an incidence rate of 5-12%.[5,10] In the current study the incidence of complex-type infections was approximately 18%, most of them were due to contamination during the urine sampling procedure. According to studies about infectious diseases occurring in an ICU setting in North America and Europe, E. coli, Pseudomonas, and Enterococcus are the most common bacterial strains in cases of ICU infections.[11] Candida species have been reported to be present at a maximal frequency of 1/3 of total cases of ICU infections.[12] In the current study, bacterial cultures showed an order of incidence of E. coli (23.1%), Pseudomonas (19.0%) and Enterococcus (17.2%) in 2011. Yeasts including Candida were detected at a rate of 15.5%. In comparison with the results that were obtained in 2001, E. coli showed no great difference. Enterococcus showed a detection rate of 15.5-17.2% despite a lack of statistical significance. In particular, Pseudomonas infections greatly increased from 10.5 to 19.0% and Klebsiella also increased from 4.2 to 10.1%. These results were in agreement with the latest Korean reports that identified the major causative bacteria for UTIs in Korea. The incidence of infections due to gram-positive bacteria was greatly increased. With regard to gram-negative bacterial infections, the incidence of infections due to E. coli decreased, and infections due to other gram-negative bacteria such as Pseudomonas, Klebsiella, and Enterobacter increased.[13,14]

Table 3. Antibiotic sensitivities for gram-stained pathogens in 2001 versus 2011.

Variables		Antibiotic Susceptibility (%)											
	Year	AC	CL	CZ	CT	GM	AK	TM	CF	LF	IP	BT	TZ
Gram (-)	2001	24.5	51.8	33.0		60.1	70.2	54.5	50.1	55.8	90.8	30.2	70.2
	2011	23.4	45.5	62.0	44.0	57.2	72.0	60.1	55.2	82.1	77.5	40.1	76.1
P		.982	.731	< .05		.684	.963	.741	.891	< .05	< .05	.0	.794
		Antibiotic Susceptibility (%)											
	Year	EM	GM	TC	AC	CL	TP	VM	CF				
Gram (+)	2001	24.5	24.1	60.1	9.2	20.4	85.4	85.7	39.5				
	2011	27.1	10.2	54.2	24.1	19.1	91.1	87.9	25.5				
P		.891	< .05	.641	< .05	.941	.791	.912	< .05				

Keys: AC = ampicillin, CL = cephalothin, CZ = ceftazidime, CT = cefotaxime, GM = gentamicin, AK = amikacin, TM = tobramycin, CF = ciprofloxacin, LF = levofloxacin, IP = imipenem, BT = bactrim, TZ = tazocin, EM = erythromycin, TC = tetracycline, TP = teicoplanin and VM = vancomycin.

In regard to antibiotic sensitivity, the emergence of bacterial resistant to antibiotics has greatly increased since the 1990s. Ko and colleagues[13] reported that ampicillin had antibacterial sensitivity in gram-negative bacteria at a rate of 15.6% in 1994 and 11.6% in 1998. With ciprofloxacin, antibacterial sensitivity has been reported to be 87.8% and 78.8% in those same years. Ryu and colleagues[15] reported that the sensitivity of gram-negative bacteria to ciprofloxacin decreased from 53.9% in 2000 to 42.6% in 2005. In the current study, sensitivity to ciprofloxacin was similarly shown a decrease at a rate of 50.1% in 2001 and 55.2% in 2011. The sensitivity to ampicillin and Bactrim was shown to be 23.4% and 40.1%, respectively. These results indicate that ampicillin and Bactrim should not be further used as the primary treatment for ICU patients with UTIs. It is also assumed that special attention should be paid to the use of quinolones. In 2005, Ryu and colleagues[15] reported that the sensitivity to penicillin and ampicillin was 40%, and sensitivity to the first-generation cephalosporin was 16% in gram-positive microorganisms. In the current study, gram-positive bacterial sensitivity to ampicillin, the first-generation cephalosporin, quinolone, and erythromycin all showed a sensitivity rate of 10-20% in 2011. These rates were overall lower than those in the report made by Ryu and colleagues.[15] This might be because only ICU patients were enrolled in the relevant studies.

An analysis of sensitivity was performed for each bacterial strain. In 2011, E. coli had sensitivity to ampicillin, ciprofloxacin, and the third-generation cephalosporin at a rate of 32.1%, 63.8% and 76-78%, respectively. Of the aminoglycosides, amikacin had a higher degree of antibacterial sensitivity as compared to gentamicin or tobramycin. However, antibiotic sensitivity for Pseudomonas was shown to be 30-45%. It was found that Pseudomonas have antibiotic resistance approximately two times higher than E. coli. In particular, the sensitivity of E. coli or Klebsiella to imipenem and tazocin was found to be at most 40-55%. According to Ryu and colleagues[15] the sensitivity of Pseudomonas to ceftazidime, cefotaxime, ofloxacin and imipenem abruptly increased in 2005 as compared to 2000. These results make it difficult to select empirical antibiotics in ICU patients with catheterization.

In the UTI cases that arose in the ICU, the most important risk factor was catheterization of the urinary system. Richards and colleagues[16] reported that more than 95% of total ICU-acquired nosocomial UTI cases were associated with catheterization. Recent reports showed that catheter-associated UTI in ICU is also very common, only secondary to ventilator-associated pneumonia both in developing and developed countries.[2,17]

This study had several limitations. Firstly, the results were based on a single group of patients from two hospitals. Therefore, the finding may not be representative of all ICU patients in our country hospitals. The sample size was small, observational nature of this study may also have affected the findings of this study. The small sample size might also explain why the results of our antibacterial testing were not in agreement with previous reports. Second, the patients types, duration of ICU stay, changes of devices, trends of Simplified Acute Physiology Score II (SAPS II), antibiotics usage duration,

Table 4. Antibiotic sensitivities for Gram-positive organisms in 2001 versus 2011.

Variables	Antibiotic Susceptibility (%)											
	Year	AC	CL	CZ	CT	GM	AK	TM	CF	LF	IP	BT	TZ
Gram (-)	2001	24.5	51.8	33.0		60.1	70.2	54.5	50.1	55.8	90.8	30.2	70.2
	2011	23.4	45.5	62.0	44.0	57.2	72.0	60.1	55.2	82.1	77.5	40.1	76.1
P		.982	.731	< .05		.684	.963	.741	.891	< .05	< .05	.061	.794
	Antibiotic Susceptibility (%)											
	Year	EM	GM	TC	AC	CL	TP	VM	CF			
Gram (+)	2001	24.5	24.1	60.1	9.2	20.4	85.4	85.7	39.5			
	2011	27.1	10.2	54.2	24.1	19.1	91.1	87.9	25.5			
P		.891	< .05	.641	< .05	.941	.791	.912	< .05			

Keys: AC = ampicillin, CL = cephalothin, CZ = ceftazidime, CT = cefotaxime, GM = gentamicin, AK = amikacin, TM = tobramycin, CF = ciprofloxacin, LF = levofloxacin, IP = imipenem, BT = bactrim, TZ = tazocin, EM = erythromycin, TC = tetracycline, TP = teicoplanin and VM = vancomycin.

trends of antibiotics consumption and etc. during 10 years may have changed. But we overlooked these factors and this can be selection bias for our result. Third, we think that short term trends (e.g. 3-5 years investigations) of organisms and antibiotic sensitivity would be more reliable and interesting. Fourth, the absence data about extended spectrum of beta lactamase (ESBL) is another limitations of present study. The ESBL is the hot issues in UTI related part from the 3-5 years before. Our study was comparing the periods of 10 years before (2001). So we could not collect the accurate data of ESBL in that period.

Future studies should involve more ICUs with many institutions; treatment regimens and comparisons of antibiotic resistance patterns between ICUs and general wards and across institutions should also be carried out to further evaluate patients with ICU-acquired UTI in Korea.

CONCLUSION

The most common bacteria responsible for the occurrence of UTIs in the ICU include E. coli, Pseudomonas, Klebsiella, and Enterococcus. In particular, Pseudomonas and Klebsiella infections were greatly increased in 2011 compared to 2001. In cases of Pseudomonas infection, the sensitivity to antibiotics was approximately two times lower than in other types of gram-negative bacterial strains. This signifies that attention should be paid to selecting optimal empirical antibiotics. Hence, further multi-center studies are required to examine the antibacterial sensitivity of bacteria causing UTIs in the ICU setting.

CONFLICT OF INTEREST

None declared.

REFERENCES

1. Edwards JR, Peterson KD, Mu Y, et al. National Healthcare Safety Network (NHSN) report: data summary for 2006 through 2008, issued December 2009. Am J Infect Control. 2009;37:783-805.
2. Dudeck MA, Horan TC, Peterson KD, et al. National Healthcare Safety Network (NHSN) Report, data summary for 2010, device- associated module. Am J Infect Control. 2011;39:798-816.
3. Moreno CA, Rosenthal VD, Olarte N, et al. Device-associated infection rate and mortality in intensive care units of 9 Colombian hospitals: findings of the International Nosocomial Infection Control Consortium. Infect Control Hosp Epidemiol. 2006;27:349-56.
4. Rosenthal VD, Maki DG, Salomao R, et al. Device-associated nosocomial infections in 55 intensive care units of 8 developing countries. Ann Intern Med. 2006;145:582-91.
5. Laupland KB, Bagshaw SM, Gregson DB, Kirkpatrick AW, Ross T, Church DL. Intensive care unit-acquired urinary tract infections in a regional critical care system. Crit Care. 2005;9:R60-5.
6. Garner JS, Jarvis WR, Emori TG, Horan TC, Hughes JM. CDC definitions for nosocomial infections, 1988. Am J Infect Control. 1988;16:128-40.
7. Di Filippo A, Casini A, de Gaudio AR. Infection prevention in the intensive care unit: review of the recent literature on the management of invasive devices. Scand J Infect Dis. 2011;43:243-50.
8. Kim JM, Park ES, Jeong JS, et al. Multicenter surveillance study for nosocomial infections in major hospitals in Korea. Nosocomial Infection Surveillance Committee of the Korean Society for Nosocomial Infection Control. Am J Infect Control. 2000;28:454-8.
9. Naber K, Bishop M, Bjerklund-Johansen T, et al. EAU guidelines on the management of urinary and male genital tract infections. EAU Working Group on Urinary and Male Genital Tract Infections. In: European Association of Urology Guidelines, 2006 ed. Arnhem: Drukkerij Gelderland; 2006. p. 1-126.

10. Tissot E, Limat S, Cornette C, Capellier G. Risk factors for catheter-associated bacteriuria in a medical intensive care unit. Eur J Clin Microbiol Infect Dis. 2001;20:260-2.

11. Gaynes R, Edwards JR, National Nosocomial Infections Surveillance S. Overview of nosocomial infections caused by gram-negative bacilli. Clin Infect Dis. 2005;41:848-54.

12. Alvarez-Lerma F, Nolla-Salas J, Leon C, et al. Candiduria in critically ill patients admitted to intensive care medical units. Intensive Care Med. 2003;29:1069-76.

13. Ko HS, Choi DY, Han YT. A Study of the Changes of Antibiotic Sensitivity to the Causative Organisms of Urinary Tract Infection for Recent 5 Years. Korean J Urol. 1999;40:809-16.

14. Ko YH, Oh JS, Cho DY, Bea JH, Koh SK. Changes of Causative Organisms and Antimicrobial Sensitivity of Urinary Tract Infection between 1979 and 2001. Korean J Urol. 2003;44:342-50.

15. Ryu KH, Kim MK, Jeong YB. A Recent Study on the Antimicrobial Sensitivity of the Organisms that Cause Urinary Tract Infection. Korean J Urol. 2007;48:638-45.

16. Richards MJ, Edwards JR, Culver DH, Gaynes RP. Nosocomial infections in combined medical-surgical intensive care units in the United States. Infect Control Hosp Epidemiol. 2000;21:510-5.

17. Tao L, Hu B, Rosenthal VD, Gao X, He L. Device-associated infection rates in 398 intensive care units in Shanghai, China: International Nosocomial Infection Control Consortium (INICC) findings. Int J Infect Dis. 2011;15:e774-80.