The Effect of Urinary Catheters on Microbial Biofilms and Catheter Associated Urinary Tract Infections

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Purpose: The aims of this study were to determine relationship between biofilm producer microorganisms attached to urinary catheters (UCs) and urinary catheter-associated urinary tract infections (CAUTIs), to determine the rate of CAUTI development and the relationship between CAUTI and catheterization period in catheterized patients.

Materials and Methods: Urinary catheters from 143 inpatients who were hospitalized in Abant Izzet Baysal University Hospital Urinary Service, and urine samples of these patients before and after catheterization of urinary catheter were collected. Culture-based microbiological evaluation of urinary catheters removed from inpatient and urine samples collected from inpatients were performed before and after catheterization of urinary catheter to identify various organisms and determine biofilm production by them.

Results: The incidence of CAUTIs was 13% (18/143) in catheterized inpatients. Biofilm producer microorganisms such as *Escherichia coli* (*E. coli*), *Klebsiella pneumoniae, Pseudomonas aeruginosa, Proteus mirabilis* that were isolated from UCs removed from inpatients were found to cause CAUTI ($P < .001$).

Conclusion: Incidence of CAUTIs is increased by the usage of UCs and prolonged catheterization period.

Keywords: urinary catheter; biofilm; catheter-associated urinary tract infection; *Escherichia coli; Klebsiella pneumonia; Pseudomonas aeroginosa; Proteus mirabilis.*

INTRODUCTION

Biofilm infections cause problems in hospitalized and immunocompressed patients.(1) Indwelling device related urinary tract infections are one of the most common biofilm infections of the urinal system.(2,3) In Europe, the mortality rate of nosocomial infections is 10%, 97% of which are related with catheters.(4) Approximately 80% of nosocomial urinary tract infections are associated with indwelling urinary catheters.(5)

Urinary bladder infection that is associated with biofilm causes failure in the drainage of urine due to congestion of catheter lumen that can be caused by crystalline debris of biofilms.(4) Biofilm embedded bacterial communities can be made up of heterogeneous cells that can resist immune defence and antibiotics because of their low metabolic activity caused by nutrient and oxygen limitations at the lower parts of the biofilm, decreased penetration of antibiotics through biofilm caused by binding of antibiotics to the structural contents of the biofilm matrix.(1) Biofilms have an important role in the pathogenesis of bacteria in indwelling device related infections. Biofilms are formed by bacteria, which attach to biotics such as, tissues, or abiotic surfaces such as, medical devices and are slime-like glycocalyx. After colonization of bacteria, mature biofilms disperse which leads to bacterial spread to the whole body.(6, 7,8) Antimicrobial resistant indwelling device related infections can cause chronic and recurrent infections. (1) Untreated urinary tract infection (UTI) can lead to acute pyelonephritis, chronic renal infection, bacterial vaginosis, chronic bacterial prostatitis, bacteraemia and death.(3)

Enterococcus spp. especially *Enterococcus faecalis*, Methicillin resistant *Staphylococcus aureus* (MRSA), *Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Proteus mirabilis, Staphylococcus epidermidis, Providencia stuartii* and *Morganella morganii* are the main urinary pathogens that cause biofilm related urinary tract infections.(3,9)

The aims of this study were to determine relationship between biofilm producer microorganisms attached to urinary catheters (UCs) and urinary catheter associated urinary tract infections (CAUTIs), to determine the rate of CAUTI development and the relationship between CAUTI and catheterization period in catheterized patients.

MATERIALS AND METHODS

Study population

All patients who had been hospitalized in Urology

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Table 1. All processes of methods

Urine Sample Before Catheterization	Urine Sample After Catheterization	Urinary Catheter
Culturation of urines	Culturation of urines	Culturation of tips of catheters
Identification of isolates	Identification of isolates	Identification of isolates
Antibiotic susceptibility tests	Antibiotic susceptibility tests	Antibiotic susceptibility tests
Assessment of biofilm Production	Assessment of biofilm Production	Assessment of biofilm production
a) Qualitative Determination of Biofilm	a) Qualitative Determination of Biofilm	a) Qualitative Determination of Biofilm
Congo red agar method (CRA)	Congo red agar method (CRA)	Congo red agar method (CRA)
Tube method (TM)	Tube method (TM)	Tube method (TM)
b) Quantitative Determination of Biofilm	b) Quantitative Determination of Biofilm	b) Quantitative Determination of Biofilm
Microtiter plate assay	Microtiter plate assay	Microtiter plate assay
Urinalysis test	Urinalysis test	

Clinics of Abant Izzet Baysal University Faculty of Medicine Hospital due to health problems which did not include urinary tract infections (UTI) in a period of 6 months, were included in study. Study participants were inpatients who used urinary catheter, did not have UTI, were not immunosuppressed, had no other diseases, and did not take antibiotic prophylaxis before taking catheter out of the body. Inclusion criteria was presence of urinary catheter. Exclusion criteria were UTI, being immunosuppressed, having other diseases, and antibiotic prophylaxis before taking catheter out of the body. Informed consent was obtained from all the inpatients participated in the study. This study was approved by Ethics Committee of Clinical Studies of T.C. Haliç University, Institute of Health Sciences.

Urine samples of those patients were collected before and after catheterization of urinary catheter to evaluate urine analysis and urine cultures. Approximately 4-5 cm long tips of Foley urinary catheters were cut by sterile scalpel and transferred to the sterile urine container to culture and detect whether biofilms were formed by microorganisms grew. Urine samples taken from the patients before and after the catheterization of urinary catheter were cultured. These samples were processed and evaluated microbiologically and biochemically in Abant Izzet Baysal University Department of Biology Biochemistry Laboratory.(**Table 1**)

Study design and Evaluation

This study which was performed in prospective single center and on random inpatients was conducted in Urology Clinics of Abant Izzet Baysal University Faculty of Medicine Hospital in Bolu, Turkey. Inpatients who had urinary catheters participated in this study in the period of 6 months. After informed consent was obtained from all the inpatients participated in the study, and being approved by ethics committee, the study proceeded as explained below.

Not only development of biofilm producer uropathogens on UCs, but also positivities of urinalysis test that contains leukocyte, nitrite and microorganism, and development of biofilm producer uropathogens in urine were defined as CAUTIs.

Procedures

Analysis of urinary catheters and urine

Urinary catheters were transferred into tryptic soy broth (TSB) (Merck TM) and incubated for 24 hours at 37° C. Then, after observing microbial growth, a subsequent transfer was done into the blood and EMB agars and incubated for 24 hours at 37° C.[10] Urines were also inoculated into the blood and EMB agar and incubated for 24 hours at 37° C. Then, the microorganisms isolated from urinary catheters and urines were identified. The capability of biofilm production of microorganisms was determined by Congo red agar method, tube method and microtiter plate assay.[11,12]

Since not only microbiological growth and development of bacteriuria (higher than 10^5 cfu/mL of microorganisms grown in urine cultures)[5,13], but also the posi-

Table 2. Status of catheters and incidences

	Number	Percentage %
Urinary Catheter / Patient	143	100
Catheter Colonized	75	52
Catheter uncolonized	68	48
Total Microorganisms Isolated from Catheters	88	100
The Incidence of Biofilm Producer Microorganisms in Whole Microorganisms	18	21 (18/88)
The Incidence of Biofilm Related UTI	18	13 (18/143)
The Incidence of Biofilm Producer Microorganisms in Catheters Colonized	18	24 (18/75)

Table 3. Microorganisms isolated in urinary catheters and urine samples

Microorganisms		Urinary Catheter				Urine (After Catheterization)				CAUTI	
		Microbial Growth		Biofilm Producer		Microbial Growth		Biofilm Producer			
		No	%	No	%	No	%	No	%	No	%
S. epidermidis	MRSE	19	22	14	26	0	0	0	0	0	0
	MSSE	2	2	1	2	0	0	0	0	0	0
S. aureus	MRSA	18	20	9	17	0	0	0	0	0	0
	MSSA	2	2	2	4	0	0	0	0	0	0
E. coli		29	33	18	34	14*	78	14*	78	14*	78
Klebsiella pneumonia		4	5	1	2	1*	6	1*	6	1*	6
Candida albicans		8	9	4	8	0	0	0	0	0	0
Streptococcus spp.		3	3	1	2	0	0	0	0	0	0
Pseudomonas aeroginosa		2	2	2	4	2*	11	2*	11	2*	11
Proteus mirabilis		1	1	1	2	1*	6	1*	6	1*	6
Total		88	100	53	100	18*	100	18*	100	18*	100

Abbreviations: %, percentage; no, number.
* Parameters which defines CAUTI were compared by Pearson χ^2 test (χ^2: 49.685, $P < .001$).

tivities of leukocyte (higher than 10 leukocytes per mm^3 of urine[14]) and nitrite, and the observation of microorganism in urine microscopy[15] were criterias for the definition of CAUTI, the complete urinalysis including pH, nitrite, and microscopic (leukocyte, bacteria, crystals) were also performed.

Identification of Microorganisms

After incubation of urines and urinary catheters, microorganisms that grow on blood and EMB agar media were determined whether they are gram positive or negative according to gram staining. Identification of *S. aureus* was based upon colony morphology on blood and mannitol-salt agar, catalase and coagulase tests. Identifications of Gram negative bacteria was based upon colony morphology on EMB agar, IMVIC test, and API systems.[10]

Assessment of MRSA and MRSE

Methicillin resistance of *S. aureus* and *S. epidermidis* is determined by cefoxitin by Kirby Bauer disk diffusion method and broth microdilution method according to the Clinical Laboratory Standards Institute criteria 2013 (CLSI). Bacterial suspensions of Staphylococcal strains were prepared in Tryptic soy broth (TSB), and adjusted to 0.5 McFarland (1.10^8 cfu/mL). The staphylococcal strains from bacterial suspensions were inoculated by the spread plate method to Mueller Hinton agar, and 30 µg cefoxitin disks were put on the inoculated plate. Zone diameters of cefoxitin were measured after incubation in 24 hours at 37°C. The zone measurements were categorized into sensitive (≥ 22 mm), or resistant (≤ 21 mm for cefoxitin) categories.[16]

Assessment of Biofilm Production

a) Qualitative Determination of Biofilm

Congo red agar method (CRA). The strains isolated from urinary catheters and urines were inoculated to Congo red agar media (CRA) (Merck TM) as described by Freeman et al. (1989) to identify whether strains were biofilm producer or not.[11] The CRA medium was constructed by mixing 0.8 g of Congo red and 36 g of sucrose (Sigma, Missouri, EUA) to 37g/L of brain heart infusion (BHI) agar (Oxoid, Basingstoke, Hampshire, England). After an incubation period of 24 hours at 37°C, morphology of colonies that undergone to different colours were differentiated as biofilm producers or not. Black colonies with a dry crystalline consistency indicated biofilm producers, whereas colonies that remained pink were non-biofilm producers.

Tube method (TM). The biofilm formation of strains that were isolated from urinary catheters and urines was also detected by tube method described by Christensen et al. (1985). The strains were inoculated in polystyrene test tube which contained TSB and incubated for 24 h at 37°C.[12] The sessile strains of which biofilms adhered on the walls of polystyrene test tube were stained with saphranin for 1 hour, after planktonic cells were discharged by washing twice with phosphate buffered saline (PBS). Then, saphranin stained polystyrene test tube was washed twice with PBS to discharge saphranin stain. After air drying of the test tube, the occurence of visible film lining the walls and the bottom of the tube indicates biofilm production.[12]

b) Quantitative Determination of Biofilm

Preparation of Bacterial Suspension

Bacterial suspensions of strains that were isolated from urinary catheters and urines were prepared and adjusted to 0.5 McFarland (1.10^8 cfu/mL). This bacterial suspensions were twenty fold (1/20) diluted to gain 5.10^6 cfu/mL. Bacterial suspension was adjusted by ten fold dilution (1/10) in such a way as the final concentration become 5.10^5 cfu/mL.

Microtiter Plate Assay

180 µl of TSB and 10 µl of bacterial suspensions were inoculated into 96-well flat-bottomed sterile poly-

Table 4. The catheterization periods and microorganisms that caused catheter-associated UTI

		Microorganisms Isolated in Urinary Catheters		**Microorganisms Isolated in Urines**		**Urinalysis**			
Cath Per.	Sex	M.o.s	Biofilm	M.o.s	Biofilm	M.o.s in Urine (cfu/mL)	Leuko. (per mm^3 of urine)	pH	Nitrite
1	F	*P. aeroginosa*	Positive	*P. aeroginosa*	Positive	> 10^5	> 10	6.5	+
1	F	*E. coli*	Positive	*E. coli* (ESBL +)	Positive	> 10^5	> 10	5	+
1	M	*E. coli*	Positive	*E. coli* (ESBL +)	Positive	> 10^5	> 10	5	+
1	M	*E. coli*	Positive	*E. coli* (ESBL +)	Positive	> 10^5	> 10	8	+
2	F	*E. coli*	Positive	*E. coli*	Positive	> 10^5	> 10	6.5	+
2	M	*E. coli*	Positive	*E. coli*	Positive	> 10^5	> 10	6.5	+
2	F	*P. aeroginosa*	Positive	*P. aeroginosa*	Positive	> 10^5	> 10	6.5	+
2	M	*K. pneumonia*	Positive	*K. pneumonia*	Positive	> 10^5	> 10	5	+
3	F	*E. coli*	Positive	*E. coli*	Positive	> 10^5	> 10	6.5	+
4	M	*E. coli*	Positive	*E. coli* (ESBL +)	Positive	> 10^5	> 10	6.5	+
4	F	*E. coli*	Positive	*E. coli*	Positive	> 10^5	> 10	6.5	+
4	F	*E. coli*	Positive	*E. coli*	Positive	> 10^5	> 10	6.5	+
7	F	*E. coli*	Positive	*E. coli* (ESBL +)	Positive	> 10^5	> 10	7.5	+
7	M	*E. coli*	Positive	*E. coli*	Positive	> 10^5	> 10	6.5	+
7	F	*E. coli*	Positive	*E. coli*	Positive	> 10^5	> 10	6.5	+
7	M	*E. coli*	Positive	*E. coli* (ESBL +)	Positive	> 10^5	> 10	5	+
8	M	*Proteus mirabilis*	Positive	*Proteus mirabilis*	Positive	> 10^5	> 10	6.5	+
21	M	*E. coli*	Positive	*E. coli*	Positive	> 10^5	> 10	5.5	+

Abbreviations: Cath. per., Catheterization periods; M.o.s, Microorganisms; Leuko, Leukocytes; F, Female; M, Male.

styrene microplate (LP Italiana SPA TM) to obtain 5.10^5 cfu/mL as a final concentration (ten fold dilution (1/10)). Uninoculated wells containing sterile TSB were used as negative controls. Microplates incubated at 24 h at 37°C. The sessile isolates of which biofilms formed on the walls of wells of microplate were stained with saphranin for 1 hour, after planktonic cells in wells of microplate had discharged by washing twice with phosphate-buffered saline (PBS) (pH 7.2) and wells had dried at 60 °C for 1 h.[12] Then, saphranin stained wells of microplates were washed twice with PBS to discharge saphranin stain. After air drying process of wells of microplate, biofilms lined the walls of the microplate were measured spectrophotometrically at 595 nm by a microplate reader (Thermo Instruments TM). The studies were repeated in triplicates. Uninoculated

Table 5. The percentages of CAUTIs according to catheterization periods

Catheterization days	Inpatient with CAUTI	Inpatient without CAUTI	Total Inpatient
≤ 4	9% (12/127)*	91% (115/127)*	127
> 4	38% (6/16)*	62% (10/16)*	16

Abbreviations: CAUTI, catheter-associated urinary tract infection
* Parameters which defines CAUTI were compared by Pearson χ^2 test (χ^2: 20.232, $P < .001$).

wells containing sterile TSB that were considered to be the negative controls used as blanks. The blank absorbance values were used to identify whether biofilm formation of isolates exist or not. The wells of isolates of which OD values are higher than blank well are considered to be biofilm producers.

The Statistical Analysis

The data were analyzed by the SPSS software version 21 that is licensed to Istanbul University. Pearson χ^2 test was used to detect existence of significance between the cultures of urinary catheter and urine, and between urine samples that were taken before and after catheterization. As a result of which existence of significance between the urinary catheter and biofilm related urinary tract infection were detected. All results were considered statistically significant if the p-value was equal to or less than 0.05.

RESULTS

143 urinary catheter samples were collected from inpatients (age ranges from 20 to 75, 33 female, 110 male) who had been hospitalized in Urology Clinics of Abant Izzet Baysal University Faculty of Medicine Hospital due to health problems which did not include urinary tract infections (UTI) in a period of 6 months.

88 strains of microorganisms were isolated from urinary catheters of 68 patients among 143 (**Table 2**). 18 strains of microorganisms were isolated from the urines that were taken after catheterization of inpatients, but, on the other hand, no microorganisms were found in any urine samples taken before catheterization. The strains of *E. coli, Klebsiella pneumonia, Pseudomonas aeroginosa* and *Proteus mirabilis* were isolated from the urines that were taken after catheterization of inpatients (**Table 3**). Not only growth of definite species in biofilms of urinary catheters were observed, but also heterogeneous microorganisms grew in biofilms of urinary catheters. Heterogeneous microorganisms that grew in biofilms of urinary catheters were, mostly, *Candida albicans*, MRSA and *E. coli*.

Some of the isolates from the urinary catheters including *E. coli, Klebsiella pneumonia, Candida albicans, Streptococcus* spp., MRSA, MSSA, MRSE and MSSE were found to be biofilm producers only; on the other hand, some of the isolates of *E. coli, Klebsiella pneumonia, Pseudomonas aeroginosa* and *Proteus mirabilis* were found to be both biofilm producers and cause catheter-associated UTIs (CAUTIs) (**Tables 3 and 4**) ($P < .001$). Six of *E. coli* strains were found to be the extended spectrum beta-lactamase producers (ESBL). The values of complete urinalysis of catheterized inpatients such as positivity of leukocyte and nitrite, and bacteria seen in urine microscopy supported CAUTIs of catheterized inpatients (**Table 4**). The incidences of *E. coli, Pseudomonas aeroginosa, Klebsiella pneumonia* and *Proteus mirabilis* that caused CAUTIs were 78%, 11%, 6% and 6%, respectively (**Table 3**).

The incidences of CAUTIs were 27% (9/33) and 8% (9/110) among female and male, respectively. The incidences of CAUTIs caused by *E. coli* and *Pseudomonas aeroginosa* were 21% (7/33) and 6% (6/33) among female, respectively. The incidences of CAUTI caused by *E. coli, Klebsiella pneumonia* and *Proteus mirabilis* were 6% (7/110), 1% (1/110) and 1% (1/110) among male, respectively (**Table 4**).

Although, four strains of *E. coli*, four strains of *Candida albicans*, one strain of *Streptococcus* spp. and 26 strains of *S. aureus* and *S. epidermidis* isolated from urinary catheter of patients were biofilm producers, they were not found to cause UTIs (**Table 3**).

18 strains of microorganisms isolated from urinary catheters of patients were found to be biofilm producers and caused biofilm or CAUTIs. The incidence of biofilm related UTI was 13% (18/143) in catheterized inpatients. The incidence of biofilm producer microorganism was 21% (18/88) among all microorganisms that were isolated from colonized urinary catheters (**Table 2**). Leukocytes and microorganisms were observed in urine microscopy, nitrite were positive, and at least 10^4 cfu/mL of microorganisms grow in urine cultures of these 18 catheterized inpatients who also showed clinical symptoms of UTI. These data show that biofilm producer microorganisms that can adhere to urinary catheters facilitate adhesion, colonization of microorganisms and cause UTI in catheterized patients ($P < .001$).

The incidence of CAUTI in patients who were catheterized four days and below, and above four days were 9% (12/127) and 38% (6/16), respectively (**Table 5**). 91 percent of inpatients who were catheterized four days and below and 62 percent of inpatients who were catheterized four days and above did not have CAUTI.

DISCUSSION

In our study, *Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Proteus mirabilis* were found to be the main urinary pathogens that cause catheter-associated urinary tract infection (CAUTIs). Alves et al., as well as Kucheria et al. also concluded that these pathogens were the main urinary pathogens[3,17] (**Table 3**).

Urinary tract infection is caused by bacteria that colonize urinary catheters produce biofilm and disperse to the bladder. Diagnosis of symptomatic CAUTI varies. CAUTI is defined based on microbiological growth, development of bacteriuria and UTI symptoms during and after catheterisation period.[5] Stenzelius defined CAUTI as bacteriuria higher than 10^5 cfu/mL of microorganisms grown in urine cultures and urinary symptoms during and after catheterization period.[18] Thibon defined

UTI as bacteriuria (higher than 10^5 cfu/mL of microorganisms grown in urine cultures) with higher than 10 leukocytes per mm^3 of urine.[14] Karchmer defined UTI as bacteriuria equal and higher than 10^5 cfu/mL of microorganisms grown in urine cultures.[13] According to the Center for Disease Control and Prevention (CDC), the positivities of leukocyte, and nitrite, the observation of microorganism in urine microscopy, and at least 104 cfu/mL of microorganisms grown in urine cultures of catheterized patients indicates CAUTIs.[15] In our study, these parameters were positive in inpatients who had CAUTIs, and they also showed clinical symptoms of UTI. However, high and rising of urine pH leads crystallization in urine that promotes biofilm formation.[19] In our study, urine pHs of inpatients who had CAUTI ranged 5-8. Urine pHs of two inpatients who had CAUTI elavated from 5 and 5.5 to 8 and 7.5, respectively. Rising of pH in urine can be due to the ability of urease production of bacteria that colonize urinary catheter.[19] Although four strains of *E. coli*, four strains of *Candida albicans*, one strain of *Streptococcus* spp. and 26 strains of *S. aureus* and *S. epidermidis* that were isolated from urinary catheters of inpatients and found to be biofilm producers, these isolates were not present in urine samples of patients, and inpatients did not show clinical symptoms of UTI. So, these isolates did not cause urinary tract infection. The reason for this may be due to undetachment of biofilm, so sessile microorganism did not disperse from catheter to urine and did not cause UTI till that time. When the biofilm embedded microorganism are detached and dispersed, they cause UTI. It is hard to identify microorganism and biofilm in urine before UTI due to the down-regulation of phenol soluble modulins (PSMs) since microorganisms are just identified in the dispersal stage of biofilm that is caused by PSMs.[20,21,22] Another reason might be due to pH of urines that are not optimum for microbial growth. Generally, pH of the urine ranges between 5 to 8.5. Above pH 7.5, and below pH 6.5 bacteria can not grow effectively. The optimum pH for bacteria and yeast growth ranges from 6.5 to 7.5 and from 5 to 6, respectively.[23] This result can also be explained by short catheterization period. Decreased catheterization period of patient reduces the risk of CAUTI. Prolonged catheterization period of patient increased the incidence of CAUTI.[24] If catheterization period of these inpatients were prolonged, risk of CAUTI would be increased.

In our study, six patients that had CAUTI were catheterized more than 4 days. One patient that had CAUTI was catheterized for a period of 21 days. Twelve patients that had CAUTI were catheterized below 4 days (Table 4). The incidence of CAUTI in patients who were catheterized four days and below, and above four days were 9% (12/127) and 38% (6/16), respectively (Table 5). According to our study, prolonged catheterization period increases the risk of CAUTI ($p < 0.05$). Incidence of bacteriuria development in patients who has urinary catheter is 5%. When catheterization period prolonges to more than 7 and 14 days, incidence of bacteriuria development rises to 35% and 70 %, respectively.[5]

Crouzet et al. reported that termination of catheterization at the fourth day decreased the incidence rate of CAUTI from 10.6 to 1.1.[24] Dohnt et al. found that incidence rate of CAUTI of short term (to 7 days) and long term catheterized patients (28 days) were approximately 50% and 100%, respectively.[25] In our study, biofilm producer *Proteus mirabilis* that was isolated in urinary catheter was also isolated in urine of an inpatient who was catheterized for 8 days (**Table 4**). *Proteus mirabilis* that does not cause UTI in short catheterization period, causes UTI in prolonged catheterization.[4]

In addition to prolonged catheterization period, the risks of CAUTI of inpatients, may be enhanced with older age, female sex and immunosuppression due to other diseases.[26] In our study, patients who had CAUTI were not immunosuppressed, had no other diseases, and half of the patients were female.

Another study revealed that, before taking catheter out of the body, antibiotic prophylaxis decreased the incidence of UTI [27, 28], while antibiotic resistance can be emerged by prophylaxis.[29] In our study, antibiotic prophylaxis was not given to catheterized inpatients before taking catheter out of the body.

CONCLUSIONS

According to this study, incidence of CAUTIs is increased by the usage of urinary catheters and prolonged catheterization period. To prevent incidence rate of CAUTIs increased by the usage of urinary catheters and prolonged catheterization period, urinary catheters must be inserted to patient with the aseptic techniques. Urinary catheters must be also removed and frequently renewed with a new ones to prevent CAUTI especially in immunosuppressed patients. Urethral injury facilitating bacterial adhesion can be prevented by the usage of lubricant during the insertion of catheter. Antimicrobial incorporated catheters can be used to decrease risks of CAUTI.

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