Biofilm Formation, Antimicrobial Resistance and Biofilm-Related Genes among Uropathogens Isolated from Catheterized Uro-Oncology Patients

Solmaz Ohadian Moghadam1, Mohammad Reza Nowroozi1, Ali Nowroozi1,2, Asieh Yousefi Kashi1

ABSTRACT

Background & Objective: Despite the critical importance of catheter as an indwelling medical device, its prolonged utilization in hospitalized patients may lead to infection. This study aimed to identify distribution of uropathogenic bacteria isolated from catheterized uro-oncology patients, their biofilm production, and antimicrobial resistance patterns to generally used antibiotics.

Materials & Methods: The urine samples of catheterized urology cancer patients were collected for urinalysis and urine culture. Then capability of biofilm production was detected by Congo red agar method, tube method, and microtiter plate assay. Antimicrobial susceptibility test was also performed using the Kirby–Bauer disc diffusion method on Muller–Hinton agar. Subsequently, polymerase chain reaction (PCR) assays were used to detect the biofilm encoding genes.

Results: Of the 100 urinary catheter samples, 76 isolates were recovered from urinary catheters of 52 patients. Escherichia coli was established to be the most frequent pathogen isolated from the urine of patients followed by Pseudomonas and Staphylococcus. All of Pseudomonas aeruginosa and Methicillin-resistant Staphylococcus aureus (MRSA) isolates were found to be biofilm producers. All studied isolates were found resistant to ampicillin, amoxicillin, and cephalxin. All biofilm-producer MRSA and Pseudomonas isolates were found to harbor the virulence genes studied. Both imipenem and fosfomycin were the most effective antibiotics against isolated bacteria.

Conclusion: In our study virulent pathogens with highly-resistant profile and potential to form biofilm were isolated from uro-oncology patients. Therefore, the current study highlights the significance of antibiotic resistance which can lead to treatment failure.

Keywords: Prostate cancer, Urinary bladder cancer, Biofilm, Antimicrobial drug resistance

Introduction

Implantable medical devices can be colonized by bacteria (1), therefore a dynamic microbiology of biofilm exists on an indwelling catheter with permanent acquire of new microorganisms at a rate of almost 3–7 percent each day (2). Routine use of catheters in urology practices and their contamination, causes an increasing challenge of catheter-associated urinary tract infections (CAUTIs) with the subsequent enhancement of morbidity and mortality (3), increased length of hospital stay, and increased treatment costs (4). CAUTIs remain among the major complications of indwelling devices (5) and comprise approximately 80% of all nosocomial UTIs. Moreover, UTIs account for about 40 percent of all health care-associated infections (5). Prolonged catheterization up to 30 days leads to CAUTI development in 100% of patients (2). In addition, CAUTIs can lead to more serious complications including bloodstream infections and endocarditis. Around 20% of health care-acquired bacteremia in intensive care units (ICUs) and over 50% in long term care centers are due to CAUTI (6). Moreover, 13,000 deaths every year are estimated to be linked to healthcare-associated UTIs in USA (7).

Biofilms can be formed on the prostate stones or urothelium and are able to colonize the surfaces of implanted medical devices (8). Biofilm formation initiates immediately after catheterization and involves both the interior and exterior surfaces of catheter (8). Biofilms are organized accumulation of bacterial cells on a surface embedded within a polymeric matrix.
created by bacteria (9). Bacterial attachment begins through adherence to surface receptors of host cell or catheter (10). A worrying characteristic of biofilm-related infections is higher resistance of biofilm-embedded bacteria on the inner surface of catheters to antimicrobial agents as well as resistance to phagocytosis and other components of the immune defense system, compared to their free-living counterparts (11). Therefore, recurrent infection occurs after antibiotic treatment is completed (12), making the bacteria to be a serious obstacle for the patient's recovery process (13). In addition, mature biofilms disperse and cause bacterial spread to the whole body (14). The patient's treatment based on antibiotic susceptibility test results of planktonic bacterial cells, which largely differs from the biofilm mode, results in treatment failure (8). Nosocomial infections due to antibiotic-resistant pathogens in cancer patients can increase the mortality rates to much higher rates (15). In spite of the importance of CAUTIs particularly in cancer patients, they have been underestimated in research. This might be due to scant surveillance and lack of regular reporting systems for intervention and prevention activities (13).

To our best knowledge, there has been no report on antimicrobial susceptibility pattern and biofilm production of uropathogenic bacteria from catheterized urology cancer patients in Iran. Therefore, we aimed to evaluate the distribution of uropathogenic bacteria isolated from catheterized uro-oncology patients, their biofilm production, and antimicrobial resistance patterns to generally-used antibiotics.

Materials and Methods

Bacterial isolation

Of the 100 urinary catheter samples, 76 bacterial isolates were recovered from urinary catheters of 52 hospitalized men in urology ward of Imam Khomeini Hospital, affiliated to Tehran University of Medical Sciences from February 2020 to April 2021.

The patients already diagnosed with UTI before catheterization, immunosuppressed patients, and those who had received antibiotic prophylaxis were excluded. Urine samples of eligible cases were collected within the first 48 hours of catheterization using a sterile syringe to puncture the catheter tube. This study was approved by institutional review board (Ethical ID: IR.TUMS.IKHC.REC.1399.014).

In the microbiology laboratory, the urine samples were inoculated directly onto tryptic soy broth (TSB), blood agar, MacConkey agar, and Mannitol salt agar (MSA) (24 hrs. /37° C, aerobic atmosphere).

Then the isolates from urine cultures were recognized using standard microbiological processes (Gram staining and colony morphology on the respective media including MSA, MacConkey agar, blood agar, Enterococcus selective agar, and cetrimide agar, biochemical tests such as catalase production, bacitracin resistance, DNase and coagulate production, fermentation of mannitol for Gram-positive bacteria and, lactose fermentation, nitrate reduction, Simmons’ citrate, Methyl red/Voges–Proskauer, urease, triple sugar iron, H2S production, and motility for Gram-negative bacteria).

Detection of methicillin-resistant Staphylococcus aureus (MRSA)

The cefoxitin (30 μg) discs were used for cefoxitin disc diffusion test to detect methicillin resistance in Staphylococcus aureus isolates as described earlier (16). Bacterial DNA was extracted by a DNA extraction kit (Qiagen, Valencia, USA) according to the manufacturer's guidelines. Polymerase chain reaction (PCR) assay targeting the mecA gene was also performed for methicillin- resistance confirmation (17).

Biofilm formation tests

The capability of biofilm production of microorganisms was detected by tube method, Congo red agar (CRA) method, and microtiter plate assay.

Slime assay on CRA

Bacterial slime production was detected by the CRA method as described before (9). The isolates were inoculated to CRA media (Merck TM) in aerobic condition at 37° C for 72 hours. Based on the colony color, they were differentiated as slime-producers (Black colonies with irregular, dry, and crystal-like appearance) or non-slime producers (pink and smooth and flat colonies with a dark center). All tests were carried out in triplicate.

Colorimetric microtiter plate method

The ability of bacteria to produce biofilm was quantified by their cultivation on a 96-well flat-bottomed polystyrene microtitre plate as described before (18). Briefly, standardized bacterial suspension (0.5 McFarland (1.5x10^8 cfu/mL) was prepared and inoculated in TSB complemented with 1% glucose [TSB was used for dilution of bacterial suspensions (1:100)]. After incubation (48hrs., 37°C), the wells were aspirated and washed three times with 300 μL phosphate-buffered saline (PBS; pH 7.2) to eliminate non-adherent bacterial cells, and attached bacteria were fixed by heat and stained with crystal violet (2%) for 15 minutes. The additional stain was rinsed off with 300 μL distilled water three times. Subsequently, the plates were air dried and resolubilized with 200 μl ethanol (95%) for 30 minutes to extract the purple crystal from biofilms. Finally, the optical densities (ODs) of adherent bacterial films which had been stained were recorded by automated ELISA at a wavelength of 570 nm. All tests were accomplished for each isolate in triplicate. The wells with TSB alone were used as negative control.

Average OD values of negative controls and samples were calculated. Cut-off value (ODc) was described as
a three-standard deviation (SD) above the mean OD of the negative control. For explanation of the adherence ability, strains were classified into four groups: nonbiofilm producer (0) OD ≤ ODc, weak biofilm producer (+ or 1) = ODc < OD ≤ 2×ODc, moderate biofilm producer (++ or 2) = 2×ODc < OD ≤ 4×ODc, and strong biofilm producer (+++or 3), 4×ODc < OD. In all biofilm formation experiments, S. epidermidis ATCC 35984 was used as positive control.

Christensen test tube method (TM)

The TM was performed after the modification of a procedure described by Christensen GD et al (19). Briefly, approximately 10 mL of TSB was inoculated with a loop full of bacteria from overnight cultures and incubated (48 hrs, 37°C). Then the walls of glass test tube were stained with crystal violet for 1 hour and then air dried. A detectable film that lined the interior tube were stained with crystal violet for 1 hour and then air dried. A detectable film that lined the interior tube wall was considered as positive slime formation. A stained ring at the liquid–air edge was reflected as negative result. The test was performed in triplicate.

Antimicrobial susceptibility testing.

Antimicrobial susceptibility test was accomplished using the Kirby–Bauer disc diffusion method on Muller–Hinton agar (Oxoid Ltd.), according to the clinical and laboratory standards institute (CLSI) guideline (20). Multiple-drug resistance (MDR) was described as bacterial resistance to at least one agent in three or more antimicrobial categories (21). The assessed antibiotics were those generally used in treatment of CAUTI and approved for bacterial infection treatment. The susceptibility profiles were determined for gentamicin (10 μg), norfloxacin (10 μg), nitrofurantoin (300 μg), ciprofloxacin (5 μg), amoxicillin (30 μg), ampicillin (10 μg), trimethoprim/sulfamethoxazole (1.25 μg/23.75 μg), tetracycline (30 μg), erythromycin (15 μg), amikacin (30 μg), ceftiraxone (30 μg), imipenem, fosfomycin, and cephalixin (Mast Diagnostics, Mast Group Ltd, Merseyside, UK). Finally, antibiotic susceptibility profiles of biofilm-forming and nonbiofilm-forming bacterial isolates were compared.

Molecular identification of genes encoding biofilm and virulence factors

Genomic DNA of bacterial isolates were extracted by a Dneasy kit (Qiagen, Valencia, CA) according to the manufacturer, and the purified DNA was used for subsequent molecular evaluations. PCR assays were used to detect the biofilm encoding genes separately (icaA and icaD genes in Staphylococcus aureus and cap A gene in Pseudomonas aeruginosa). Detection of genes encoding virulence factors in Escherichia coli that cause urinary tract infection including hemolysin (hly), P fimbriae (papC), type 1 fimbriae (fimA) was also carried out by the PCR method using specific primers as previously described (22) (Table 1). The genes were amplified on an Eppendorf (Hamburg, Germany) thermocycler (Table 1) in a volume of 25 μL with SinaClon PCR Master Mix 2X containing 1 μl of each primer (20 pmol) (Table1), 2 μl of DNA template, 12.5 μL of PCR Master Mix 2X, and H2O to achieve a final reaction volume of 25 μL.

Results

Uropathogen isolation

Totally 76 uropathogen isolates were recovered, of which Escherichia coli was shown to be the most frequent pathogen isolated followed by Pseudomonas and Staphylococcus. The frequencies of different bacteria isolated from patients are summarized in Table 2.

Biofilm formation

Slime production by urinary isolates were explored by three mentioned methods. According to microtiter plate method and tube method, the incidence of biofilm-producer bacteria was 82% (63/76). All of Pseudomonas aeruginosa and MRSA isolates were found to be biofilm formers. The results of biofilm production in urinary isolates using three different methods are summarized in Table 3.

<table>
<thead>
<tr>
<th>Bacterium</th>
<th>Gene</th>
<th>Primer Sequence</th>
<th>Product size(bp)</th>
<th>PCR program cycle parameters</th>
<th>Standard strain positive for the gene of interest</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staphylococcus aureus</td>
<td>meCA</td>
<td>F - TCAGATATCAACCTCACCAGG G - CCACCCTATCTTTGAAACG</td>
<td>447</td>
<td>Initial denaturation 94°C for 1 min, annealing 55°C for 1 min, extension 72°C for 2 min</td>
<td>ATCC29247</td>
<td>9</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>hly</td>
<td>F - TCAGATATCAACCTCACCAGG G - CCACCCTATCTTTGAAACG</td>
<td>447</td>
<td>Initial denaturation 94°C for 1 min, annealing 55°C for 1 min, extension 72°C for 2 min</td>
<td>ATCC29247</td>
<td>9</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>papC</td>
<td>GAGCGCGCGGCGGGTTGGCC G - GCCAGGATATAGAGGACGG</td>
<td>328</td>
<td>Initial denaturation 94°C for 1 min, annealing 55- 62°C depending on gene for 1:30 min, extension 72°C for 2 min</td>
<td>ATCC 27835</td>
<td>23</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>fimA</td>
<td>F - GTTAGTGTGGTTGCTGTTGCT G - AGTGTTGTTGCTGTTGCT</td>
<td>447</td>
<td>Initial denaturation 94°C for 1 min, annealing 55- 62°C depending on gene for 1:30 min, extension 72°C for 2 min</td>
<td>ATCC 25922</td>
<td>22</td>
</tr>
</tbody>
</table>

Table 2. The frequencies of different bacteria isolated from urine samples

<table>
<thead>
<tr>
<th>Bacterium</th>
<th>Gene</th>
<th>Product size(bp)</th>
<th>PCR program cycle parameters</th>
<th>Standard strain positive for the gene of interest</th>
<th>Reference</th>
</tr>
</thead>
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<tr>
<td>Staphylococcus aureus</td>
<td>meCA</td>
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<td>ATCC 25922</td>
<td>22</td>
</tr>
</tbody>
</table>
Resistant bacteria in catheterized cancer patients

<table>
<thead>
<tr>
<th>Bacterial isolates, (N = 76)</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Escherichia coli</strong></td>
<td>29 (38.1)</td>
</tr>
<tr>
<td><strong>Staphylococcus aureus</strong></td>
<td></td>
</tr>
<tr>
<td>MSSA</td>
<td>5 (6.6)</td>
</tr>
<tr>
<td>MRSA</td>
<td>16 (21.0)</td>
</tr>
<tr>
<td><strong>Pseudomonas aeruginosa</strong></td>
<td>16 (21.0)</td>
</tr>
<tr>
<td><strong>Enterobacter spp.</strong></td>
<td>6 (8)</td>
</tr>
<tr>
<td><strong>Klebsiella spp</strong></td>
<td>3 (4)</td>
</tr>
<tr>
<td><strong>Proteus mirabilis</strong></td>
<td>1 (1.3)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>76 (100)</td>
</tr>
</tbody>
</table>

Table 3. Results of biofilm production among bacterial isolates using three different methods

<table>
<thead>
<tr>
<th>Strains (n)</th>
<th>Method</th>
<th>Microtitre Plate Method N(%)</th>
<th>CRA Method N(%)</th>
<th>Tube Method N(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Escherichia coli</strong> (29)</td>
<td>NBP: 9 (31.0)</td>
<td>WBP: 1(3.5)</td>
<td>MBB: 1(3.5)</td>
<td>SBP: 18(62.0)</td>
</tr>
<tr>
<td><strong>Staphylococcus aureus</strong> (5)</td>
<td>NBP: 3(60)</td>
<td>WBP: 2(40)</td>
<td>MBB: 0</td>
<td>SBP: 3(60)</td>
</tr>
<tr>
<td><strong>Pseudomonas aeruginosa</strong> (16)</td>
<td>NBP: 0</td>
<td>WBP: 0</td>
<td>MBB: 2(12.5)</td>
<td>SBP: 14(87.5)</td>
</tr>
<tr>
<td><strong>Enterobacter spp.</strong> (6)</td>
<td>NBP: 1(16.7)</td>
<td>WBP: 0</td>
<td>MBB: 4(66.6)</td>
<td>SBP: 1(16.7)</td>
</tr>
<tr>
<td><strong>Klebsiella spp</strong> (3)</td>
<td>NBP: 0</td>
<td>WBP: 0</td>
<td>MBB: 0</td>
<td>SBP: 3(100)</td>
</tr>
<tr>
<td><strong>Proteus mirabilis</strong> (1)</td>
<td>NBP: 0</td>
<td>WBP: 0</td>
<td>MBB: 1(100)</td>
<td>SBP: 0</td>
</tr>
</tbody>
</table>

NBP: Non-biofilm producer; MBP: Weak biofilm producer; Moderate biofilm producer: MBP; SBP: Strong biofilm producer; BP: biofilm producer

Antimicrobial-resistance profile of bacterial isolates

All studied isolates were found resistant to amoxicillin, ampicillin, and cephalixin. Moreover, a high rate of resistance was found against gentamicin, trimethoprim/sulfamethoxazole, and erythromycin. The results showed that resistance to tetracycline, ceftriaxone, ciprofloxacin and norfloxacin were significantly different between biofilm-producing and non-biofilm-producing bacteria.

All Pseudomonas aeruginosa isolates had high frequency of resistance to all of the tested antibiotics and all of them were resistant to gentamicin. According to the MDR definition, all of the Pseudomonas aeruginosa isolated were MDR as well.

Additionally, all biofilm-former bacteria in our study were MDR. The resistance to norfloxacin and ciprofloxacin among biofilm-producing isolates was almost similar except for Pseudomonas, where the resistance rates to these two antibiotics were 12.5% and 75%, respectively.

The antibiotic susceptibility patterns of the biofilm-former isolates and nonbiofilm formers are shown in Table 4.
Table 4. The antibiotic resistance patterns of the biofilm-former and nonbiofilm former isolates

<table>
<thead>
<tr>
<th>Isolated Bacteria</th>
<th>Genotype</th>
<th>Biofilm Producer N (%)</th>
<th>Non-Biofilm Producer N (%)</th>
<th>Total N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Escherichia coli</em></td>
<td>papC/ hly/ fimA</td>
<td>20(100)/20(100)/20(100)</td>
<td>2(22.2)/2(22.2)/2(22.2)</td>
<td>22(75.9)</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>mecA/ IcaA/ IcaD</td>
<td>16(100)/16(100)/16(100)</td>
<td>-/0/0</td>
<td>16(100)</td>
</tr>
<tr>
<td><em>Pseudomonas aeruginosa</em></td>
<td>cup A</td>
<td>12(75)</td>
<td>-</td>
<td>12(75)</td>
</tr>
</tbody>
</table>

Table 5. Virulence genes among biofilm producer and non-biofilm producers of isolated bacteria

<table>
<thead>
<tr>
<th>Isolated Bacteria</th>
<th>Gene profile</th>
<th>Biofilm Producer N (%)</th>
<th>Non-Biofilm Producer N (%)</th>
<th>Total N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Escherichia coli</em></td>
<td>papC/ hly/ fimA</td>
<td>20(100)/20(100)/20(100)</td>
<td>2(22.2)/2(22.2)/2(22.2)</td>
<td>22(75.9)</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>mecA/ IcaA/ IcaD</td>
<td>16(100)/16(100)/16(100)</td>
<td>-/0/0</td>
<td>16(100)</td>
</tr>
<tr>
<td><em>Pseudomonas aeruginosa</em></td>
<td>cup A</td>
<td>12(75)</td>
<td>-</td>
<td>12(75)</td>
</tr>
</tbody>
</table>

Discussion

Nowadays, biofilm-based infections are an emerging problem in hospital settings. According to the National Institutes of Health (NIH), up to 80% of all infections are due to biofilm-producer bacteria and urology is one of the major fields in which biofilm and antibiotic resistance can become problematic (23).

Detection of genes associated with biofilm formation

All biofilm producer MRSA and Pseudomonas isolates were positive for the genes studied. In addition, none of the non-biofilm former *Pseudomonas aeruginosa* strains harbored cup A gene. The detailed results are shown in Table 5.

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appropriate antibiotic at the beginning of the treatment, thereby avoiding the need to change antibiotic in the later stages (24).

In the present study, 82% (63/76) of bacterial isolates were positive for the biofilm production (Table 4), which was higher compared with previous studies (25, 26). This might result from the fact that our study was performed only in catheterized patients.

The main biofilm -producer urinary pathogens known as ESKAPE include Enterococcus spp. especially Enterococcus faecalis, MRSA, Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Proteus mirabilis, Staphylococcus epidermidis, Providencia stuartii, and Morganella morganii (27, 28).

In the current study, Escherichia coli, Pseudomonas aeruginosa, and Staphylococcus aureus were the most frequent strains isolated from patients. This was consistent with other studies which have reported these strains as the most important pathogens isolated from urine cultures (28-30). Escherichia coli is one of the most common causes of urinary infections (31). Proteus species are also a part of human intestinal flora and are widely distributed in long-term care settings and hospitals (31). Not only can they colonize the skin and mucosa of hospitalized patient but also cause nosocomial infections (31). In our study only one of our cases was Proteus mirabilis and resistant to all of study antibiotics.

Pseudomonas is one of the most important causes of nosocomial infections and is resistant to a wide range of antibiotics (32). Our findings showed that all of Pseudomonas aeruginosa, MRSA, and Klebsiella Spp., isolated from urine samples were biofilm producer. All Pseudomonas aeruginosa isolates harbored cup A gene and had high frequency of resistance to all of the tested antibiotics. All of them were MDR as well. Furthermore, all of Pseudomonas aeruginosa isolates were resistant to gentamicin. This was contrary to the previous study in our country (32).

Klebsiella spp. are other uropathogens and have both endogenous and exogenous sources (32). Klebsiella spp comprised 4% of isolates in current study.

Biofilms have major effects on antibiotic resistance, and minimum inhibitory concentrations (MICs) of antibiotics which are essential for effective treatment (23). It is recognized that biofilm formation leads to antibiotic resistance by decreased penetration of the antimicrobial agents and altered growth rate of biofilm microorganisms. In fact, infection due to biofilm-producer bacteria means infection with highly-resistant bacteria. Our results were concordant with previous studies regarding higher antibiotic resistance in biofilm producers compared with non-biofilm producers (5, 9). However, an overall comparison between all biofilm-producing bacteria with non-biofilm producers showed that the resistance to some antibiotics such as ciprofloxacin, tetracycline, ceftriaxone, and norfloxacin was significantly higher among biofilm-producers than non-biofilm producers (Table 4). One of the limitations of the present study was the small sample size. Perhaps if the number of isolates studied were greater, the significance of antibiotic resistance would change between the two groups of biofilm producers and non-biofilm producers.

Regarding in vivo and in vitro studies, β-lactams and aminoglycosides are able to inhibit the young biofilm development; however, fluoroquinolones affect not only young biofilms but also older biofilms (33). All biofilm- former bacteria in our study were MDR and the resistance to norfloxacin and ciprofloxacin among biofilm-producing isolates was almost similar except for Pseudomonas, where the resistance rates to these two antibiotics were 12.5% and 75%, respectively. High resistance to ciprofloxacin might result from frequent use of this antibiotic as prophylaxis and empiric therapy in the last few years. Furthermore, the frequency of isolates resistant to nitrofurantoin was low. Thus, it can be considered as a treatment choice for UTI in our settings. Resistance of Pseudomonas to imipenem has been reported in the past studies in Iran within the range of 16% - 100%. In this study, the resistance was 12.5%, which was lower than a previous study (32). Thus, antibiotic susceptibility tests are recommended before empirical treatment for management of UTIs in our settings. According to our data, resistance to erythromycin was high among isolates. This is contradictory to a previous study that recommended macrolides as first-line treatment for biofilm-associated UTIs (34). Our results indicated that both imipenem and Fosfomycin had the best effect against isolated bacteria and can be considered as good choices for treatment of UTIs which is consistent with previous studies (35-38). Since the urology cancer patients are at high risk for CAUTIs, the main goal of oncology nursing is to improve patients’ safety and reduce infection rates and save their lives. This needs early intervention and adequate information about the causative agents of infections and their characteristics to make proper decision for the treatment or prevention. Therefore, antibiotic prophylaxis particularly in cancer patients, utilization of aseptic techniques and antimicrobial- incorporated catheters can reduce the incidence of CAUTI.

Conclusion

According to this study, virulent pathogens with highly-resistant profile and potential to form biofilm were isolated from uro-oncology patients. To the best of our knowledge, this is the first study that reports a significantly high spread of bacterial isolates with the potential to form biofilm among urology cancer patients in Iran.

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Conflict of Interest
The authors declare no conflict of interests.

References


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