Urinary Tract Infections in Patients with Solid Tumors: Retrospective Study

Souhir Khemiri\textsuperscript{1*}, Sonda Masmoudi\textsuperscript{1}, Sonda Mezghanni\textsuperscript{2}, Wala Ben Kridis\textsuperscript{1}, Adnène Hammami\textsuperscript{2} and Afef Khanfir\textsuperscript{1}

\textsuperscript{1}Medical Oncology, CHU Habib Bourguiba, Sfax, Tunisia
\textsuperscript{2}Bacteriology Laboratory, CHU Habib Bourguiba, Sfax, Tunisia

\*Corresponding author: Souhir Khemiri, Medical Oncology, CHU Habib Bourguiba, Sfax, Tunisia

Abstract

\textbf{Purpose:} Urinary tract infection (UTI) is one of the most common infections in patients with cancer. It may occur at different phases of the disease and results from the interaction of several factors. The objective of our study was to determinate the particularities of these infection in this special population.

\textbf{Patients and Methods:} Retrospective study including all patients followed for solid tumor in the medical oncology department CHU Habib Bourguiba Sfax who had developed at least one episode of UTI documented between 2017 and 2019.

\textbf{Results:} Forty-six patients were collected: 24 women and 22 men. The median age was 57 years. A history of diabetes and urolithiasis were found in 23.9% and 19.6% of cases respectively. The site of the primary tumor was pelvic in 30 cases (65.3%), including 17 bladder tumors, and extra-pelvic in the other cases. Ten patients (21.7%) had recurrent episodes of UI during their follow-up, including 8 cases of bladder tumors. Urinary catheters was used in ten cases. All the patients had received at least one line of chemotherapy. The majority of UTIs (82.6%) occurred during cycles of chemotherapy, 26% of which were associated with febrile neutropenia. The most common bacteria was \textit{Escherichia coli} (58.6%) which was resistant to cefotaxime and ciprofloxacin in 25% and 39.3% of cases respectively. Seven patients (15%) presented polymicrobial UTIs. The urine contained at least one multi-resistant germs in 26.1% of cases more frequently in pelvic tumors then extra-pelvic tumors (36.2% versus 8.2%; p = 0.035), in the presence of urinary catheter (70% versus 13.9% in the absence of catheter; p = 0.001) and during chemotherapy (35.7% versus 6.2% apart from chemotherapy; p = 0.02), the UTI was complicated of bacteremia in 6 cases (13%), four of which were undergoing chemotherapy and three were associated with febrile neutropenia, resulting in one case in septic shock and death.

Conclusion: It seems necessary, following this study, to implement recommendations for treatment and prevention of UTIs in solid tumors. They must be particularly adapted to the level of risk incurred by the different risk factors.

\textbf{Keywords}  
Cancer, Infection, Urinary tract

Introduction

Urinary tract infections (UTIs) are one of the most frequent infections in patients with solid tumors. Although prolonged and profound neutropenia due to chemotherapy is rare, several factors increase the risk of infection in patients followed for solid tumors and the association of multiple risk factors is not uncommon [1]. In addition, specific factors was described in this particular population such as urinary stasis secondary to obstruction caused by tumor progression, disruption of natural anatomical barriers and immunosuppression secondary to anti-cancer treatments. The increasing use of medical devices may promote these infections [2]. The epidemiology of these infections changes over time with the emergence of multi-resistant germs and polymicrobial infections are more frequently isolated. Given their frequency and their severity in a particularly fragile population, new therapeutic or even preventive approaches must be developed [3,4]. The objective of our study was to study the epidemiological and microbiological particularities of UTIs in patients with solid tumors.

Citation: Khemiri S, Masmoudi S, Mezghanni S, Kridis WB, Hammami A, et al. (2022) Urinary Tract Infections in Patients with Solid Tumors: Retrospective Study. J Clin Nephrol Ren Care 8:075. doi.org/10.23937/2572-3286.1510075
Accepted: July 26, 2022; Published: July 28, 2022
Copyright: © 2022 Khemiri S, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.
distribution). The Fisher or chi 2 test were performed for the comparison of qualitative variables. A p-value less than 0.05 was defined as the level of statistical significance.

Results

Forty six 46 cases were collected. The median age was 57 years, most (73%) aged more than 50 years. A female predominance (52%) was noted. A history of diabetes and urolithiasis was found in 23.9% and 19.6% of cases respectively. The site of the primary tumor was pelvic in 30 cases (65.3%), including 17 cases of bladder tumors, and extra-pelvic in the other cases (Table 1). All pelvic tumors other than bladder tumors were locally advanced. The majority of UTIs occurred at an advanced stage of the disease with 69.6% of the tumors were metastatic. Irritative urinary signs such as dysuria were the main revelating symptoms in 80.4% of cases. A systematic bacteriological investigation in the presence of an isolated fever was the reason for the discovery in 7 cases.

A medical device was present in ten cases (21.7%). It was a percutaneous nephrostomy tube in all cases used for decompression of ureteral obstruction due to their tumors.

Ten patients (21.7%), presented recurrent UTIs during their follow-up, including 8 cases (80%) of bladder tumors and 4 cases (40%) with nephrostomy tubes. The number of episodes varied from 2 to 5. A total of 60 UTIs were then diagnosed.

Different bacterias were isolated from urine (Table 2). The most frequent was \textit{Escherichia coli} (58.6%) followed by \textit{Klebsiella pneumoniae} (28.2%), \textit{Enterococcus faecalis} (23.9%) and \textit{Pseudomonas aeruginosa} (17.3%). Strains of \textit{Escherichia coli} were resistant to ampicillin, cefotaxime, and ciprofloxacin in 67.8%, 25% and 39.3% of cases, respectively. Strains of \textit{Klebsiella pneumoniae} were resistant to cefotaxime and imipenem in 18.75% and 15.38% of cases, respectively. Strains of \textit{Pseudomonas aeruginosa} were resistant to ceftazidime, imipenem and ciprofloxacin in 12.5% for each antibiotic. All strains of \textit{Enterococcus faecalis} were resistant to ampicillin and cefotaxime.

### Patients and Methods

The study was a retrospective analysis of the data of all the patients followed in the medical oncology department of the Habib Bourguiba Sfax University Hospital, Tunisia for a solid tumor who had developed at least one episode of UTI documented and confirmed by a Cytobacteriological examination of Urine between January 2017 and December 2019. The definition criteria for an UTI are the presence of clinical signs and a bacteriuria greater or equal to $10^5$ germs per ml or with a lower bacteriuria ($10^3$ to $10^4$ germs per ml), but associated with a leukocyturia of at least $10^4$ per ml.

For each UTI episode, we collect:

- Patient clinical data:
  - History: Such as urogenital anomaly, diabetes, bladder outflow obstruction, urodynamic anomalies...
  - The site of the solid tumor: Pelvic (bladder tumor, genital, anorectal) or extra-pelvic tumor, stage of disease at the time of the onset of the UTI episode
  - The presence or not of a medical device such as vesical catheter, ureteral stents or nephrostomy tube
  - The number of UTI episodes, time of onset (during or apart from systemic treatment) and revelating clinical signs
- Microbiological data:
  - The germs identified in each episode of UTI
  - A multi-microbial UTI was to be mentioned
  - Data of the antibiograms which were carried out for each isolated germ which were classified to sensitive or resistant character to the studied antibiotics

Data analysis was performed using 20th version of SPSS. The qualitative variables were expressed as percentages and the quantitative variables as the mean ± standard deviation after checking the normality of the distribution, and as the median if not (the non-Gaussian distribution). The Fisher or chi 2 test were performed for the comparison of qualitative variables. A p-value less than 0.05 was defined as the level of statistical significance.

### Table 1: Distribution according to the site of the primary tumor.

| Site of the Primary Tumor | Number | Tumor’s Type (Number)                                      |
|---------------------------|--------|------------------------------------------------------------|
| Pelvic                    | 30     | Bladder tumor (17)                                          |
|                           |        | Ovarian tumor (5)                                           |
|                           |        | Cervical tumor (3)                                          |
|                           |        | Low rectal tumor (2)                                        |
|                           |        | Prostate tumor (1)                                          |
| Extra-pelvic              | 16     | Digestive tract tumors other than rectum (8)                |
|                           |        | Metastatic Breast tumor (3)                                 |
|                           |        | Metastatic Lung tumor (2 others) (5)                        |

### Table 2: Distribution of isolated bacteria.

| Bacteria               | Percentage |
|------------------------|------------|
| \textit{Escherichia coli} | 58.6%      |
| \textit{Klebsiella pneumoniae} | 28.2%      |
| \textit{Enterococcus faecalis} | 23.9%      |
| \textit{Pseudomonas aeruginosa} | 17.3%      |
sensitive to ampicillin and glycopeptides (Table 3). The antibiotic treatment is initially prescribed on a broad spectrum based on cefotaxime with aminoglycoside then it would be adapted according to the antibiogram result.

All the patients received at least one line of chemotherapy. The majority of UTIs (32 cases, 82.6%) occurred during the cycles of chemotherapy, of which 12 cases or 26% were associated with grade 3 or 4 febrile neutropenia from the World Health Organization (WHO). These episodes of febrile neutropenia were all treated in hospital with broad-spectrum intravenous antibiotics. A protocol based on Gemcitabine and platinum used in the treatment of bladder tumors, whether metastatic or not, was the most implicated

Table 2: Spectrum of bacteria isolated from urine.

| Bacteria                  | Number (%) |
|---------------------------|------------|
| *Escherichia coli*        | 27 (58.6)  |
| *Klebsiella pneumoniae*   | 13 (28.2)  |
| *Enterococcus faecalis*   | 12 (26)    |
| *Pseudomonas aeruginosa*  | 8 (17.3)   |
| *Enterococcus faecium*    | 4 (8.6)    |
| *Enterobacter cloacae*    | 3 (6.5)    |
| *Streptococcus agalactiae*| 2 (4.3)    |
| *Staphylococcus aureus*   | 2 (4.3)    |
| *Proteus mirabilis*       | 1 (2.1)    |
| *Acinetobacter baumannii* | 1 (2.1)    |

Table 3: Susceptibility to antibiotics of the most frequent bacteria isolated.

| Antibiotic                  | *Escherichia coli* | *Klebsiella pneumoniae* | *Enterococcus faecalis* | *Pseudomonas aeruginosa* |
|-----------------------------|---------------------|-------------------------|-------------------------|--------------------------|
|                             | Sensitive | Resistant | Sensitive | Resistant | Sensitive | Resistant | Sensitive | Resistant |
| Ampicillin                  | 32.2%     | 67.8%     | -         | 100%      | -         | 100%      | -         | -         |
| Amoxicillin and clavulanic acid | 58.33% | 41.67% | 60% | 40% | - | - | - | - |
| Ticarcillin                 | 32.79%    | 67.21%    | -         | 100%      | -         | -         | 100%      | -         |
| Ticarcillin and clavulanic acid | 61.67% | 38.33% | 62.5% | 37.5% | - | - | 87.5% | 12.5% |
| Piperacillin                | 32.76%    | 67.24%    | -         | 100%      | -         | -         | 85.71%    | 14.29%    |
| Piperacillin and Tazobactam | 82.26%    | 17.74%    | 68.75%    | 31.25%    | -         | -         | 100%      | -         |
| Mecillinam                  | 84.75%    | 15.25%    | 92.86%    | 7.14%     | -         | -         | -         | -         |
| Cefalexin                   | 61.67%    | 38.33%    | 81.25%    | 18.75%    | -         | -         | -         | -         |
| Cefoxitin                   | 94.59%    | 5.41%     | 80%       | 20%       | -         | -         | -         | -         |
| Cefuroxime                  | 75.41%    | 24.59%    | 81.25%    | 18.75%    | -         | -         | -         | -         |
| Cefixime                    | 76.27%    | 23.73%    | 81.25%    | 18.75%    | -         | -         | -         | -         |
| Cefotaxime                  | 75%       | 25%       | 81.25%    | 18.75%    | -         | -         | -         | -         |
| Ceftazidime                 | 75.41%    | 24.59%    | 81.25%    | 18.75%    | -         | -         | 87.5%     | 12.5%     |
| Cefepime                    | 80%       | 20%       | 81.25%    | 18.75%    | -         | -         | 87.5%     | 12.5%     |
| Aztreonam                   | 80.36%    | 19.64%    | 81.25%    | 18.75%    | -         | -         | 100%      | -         |
| Ertapenem                   | 100%      | -         | 87.5%     | 12.5%     | -         | -         | -         | -         |
| Imipenem                    | 100%      | -         | 84.62%    | 15.38%    | -         | -         | 87.5%     | 12.5%     |
| Meropenem                   | 100%      | -         | 87.5%     | 12.5%     | -         | -         | -         | -         |
| Gentamicin                  | 85.45%    | 14.55%    | 66.67%    | 33.33%    | -         | -         | 100%      | -         |
| Tobramycin                  | 79.31%    | 20.69%    | 71.43%    | 28.57%    | -         | -         | 100%      | -         |
| Amikacin                    | 95%       | 5%        | 92.86%    | 7.14%     | -         | -         | 100%      | -         |
| Netilmicin                  | 87.1%     | 12.9%     | 68.75%    | 31.25%    | -         | -         | -         | -         |
| Tigecycline                 | 100%      | -         | -         | -         | -         | -         | -         | -         |
| Nalidixic Acid              | 51.67%    | 48.33%    | 62.50%    | 37.5%     | -         | -         | -         | -         |
| Norfloxacin                 | 63.64%    | 36.36%    | 71.43%    | 28.57%    | -         | -         | -         | -         |
| Ciprofloxacin               | 60.66%    | 39.34%    | 66.67%    | 33.33%    | -         | -         | 87.5%     | 12.5%     |
| Trimethoprim                | 55.74%    | 44.26%    | 53.8%     | 46.2%     | -         | -         | -         | -         |
| Trimethoprim-Sulfamethoxazole | 57.14% | 42.86% | 53.8% | 46.2% | - | - | - | - |
| Fosfomycin                  | 97.83%    | 2.17%     | 100%      | -         | -         | -         | -         | -         |
| Nalidixic Acid              | 100%      | -         | 71.43%    | 28.57%    | -         | -         | -         | -         |
| Colistin                    | -         | 10%       | 90%       | -         | -         | -         | -         | -         |
| Glycopeptide                | -         | -         | -         | 100%      | -         | -         | -         | -         |
in 12 cases (31.5%) not associated in all cases with neutropenia. It was a palliative chemotherapy in 28 cases (73.6%).

Seven patients (15.2%) presented polymicrobial UTIs. All of them had pelvic tumors and 4 cases had percutaneous nephrostomy. Mycosic infection by candida was associated in 2 cases (one patient with diabetes and metastatic bladder tumor, apart from any chemotherapy and a second patient with no particular history, with a metastatic prostate tumor having developed 5 episodes of UTI during his follow-up, which developed during chemotherapy in a context of febrile neutropenia a three-germ UTI associating Klebsiella pneumoniae, Enterococcus faecalis and Candida albicans).

We identified at least one multi-resistant germ in 26.1% of cases. A significant difference in this rate of strain resistance was noted between pelvic tumors and extra-pelvic tumors (36.2% versus 6.2%; p = 0.035), a single episode of UTI or recurrent episodes of UTI during follow-up (8.4% vs. 70%; p <0.0001), with or without urine medical devices (70% vs. 13.9%; p = 0.001) and underway or apart from chemotherapy (35.7% vs. 6.2%; p = 0.02). There was no significant difference between males and females (p = 0.48) or in patients < or > 50 years (p = 0.62).

Six UTI episodes were complicated with bacteremia, four of which were undergoing chemotherapy, four with nephrostomy tube and three cases of febrile neutropenia. One case was complicated with septic shock and death. The germs isolated in these 6 cases were equally distributed between Escherichia coli, Klebsiella pneumoniae and polymicrobial UTI. Half of them were multi-resistant strains.

Discussion

This study allowed to observe the epidemiology and microbiology of UTIs in a specific population which are patients with solid tumors. Although solid tumors are much more common, infections in this population are not as well studied as in malignant hemopathy and they constitute a much more heterogeneous population which makes these studies difficult [5,6]. Specific factors have been described and the presence of multiple risk factors in the same patient is not uncommon [1,7,8].

The risk factor most described in the literature for both solid tumors and hematologic malignancies is neutropenia [1,9]. It is defined as a neutrophil count below 2000 cells/mm³. The risk of developing infections is significant in the presence of WHO grade 3 neutropenia and major in grade 4 neutropenia which are defined by a number less than 1000 and 500 cells/mm³ respectively. The most common cause of neutropenia is chemotherapy. It can also occur after radiation therapy or the administration of other myelosuppressants (eg, ganciclovir). Neutropenia is the most serious haematological toxicity of anti-cancer treatments, often limiting the doses to be better tolerated. The degree and duration of neutropenia determine the risk of infections [10]. According to studies published in the literature, patients with solid tumors that develop febrile neutropenia are considered in the majority of cases to be at low risk of infection [11,12]. In our study, 82.6% of UTI episodes occurred during cycles of chemotherapy, WHO grade 3 or 4 febrile neutropenia was associated in only 26% of cases.

Specific guidelines for the management of febrile neutropenic patients with underlying solid tumors have recently been published [13]. They stress the importance of performing risk assessment in order to identify low-risk patients who can be treated in an ambulatory setting, since hospitalisation is associated with exposure to nosocomial infections, often with multi-resistant germs. However, the safety of this ambulatory treatment should only be implemented if an appropriate infrastructure is present [14,15]. On the other hand, the identification of high-risk patients allows them to be managed by appropriate antibiotic therapy under adequate monitoring. The risk still being the evolution on septic shock, which can be fatal [16]. Three UTI episodes (6%) in our neutropenic patients were complicated with bacteremia, leading in one case to a septic shock and death.

Another risk factor associated with an increase UTIs incidence described in solid cancers is the destruction of normal anatomic barriers. Indeed, the human body has normal anatomical barriers such as the skin and various mucous surfaces (oropharyngeal, gastrointestinal, respiratory and genitourinary) which provide an important natural defense mechanism against pathogens [17]. The innate responses use phagocytic cells (neutrophils, monocytes, and macrophages), cells that release inflammatory mediators (basophils, mastcells, and eosinophils), and natural killer cells. The molecular components of innate responses include complement, acute-phase proteins, and cytokines such as the interferons. Anti-tumor treatment such as chemotherapy often damages the mucous membranes thereby increasing the risk of infections caused by microorganisms that colonize their surfaces (e.g., viridans group streptococci (VGS), Streptococcus pneumoniae, Stomatococcus mucilaginosus, enteric Gram-negative bacilli (GNB), and anaerobes) [1]. In our study, the majority of UTIs occurred during chemotherapy treatment. The most frequent germs were enteric GNBs (Escherichia coli (58.6%), Klebsiella pneumoniae (28.2%) and Enterococcus faecalis (26%)).

These barriers can also be damaged by radiation therapy, surgery and the use of medical devices frequently used in cases of urinary obstruction or incontinence. These devices frequently promote acute or even chronic UTIs, sometimes progressing to
Enterococcus faecalis three-germ UTI associating chemotherapy in a context of febrile neutropenia of UTI during his follow-up, which developed during metastatic prostate tumor having developed 5 episodes in 2 cases (one patient with diabetes and metastatic tumors, therefore requiring chemotherapy) [25]. A candida was isolated in 2 cases (one patient with diabetes and metastatic tumors, therefore requiring chemotherapy) [25]. A candida was isolated in 2 cases (one patient with diabetes and metastatic tumors, therefore requiring chemotherapy) [25]. A candida was isolated in 2 cases (one patient with diabetes and metastatic tumors, therefore requiring chemotherapy) [25]. A candida was isolated in 2 cases (one patient with diabetes and metastatic tumors, therefore requiring chemotherapy) [25]. A candida was isolated in 2 cases (one patient with diabetes and metastatic tumors, therefore requiring chemotherapy) [25]. A candida was isolated in 2 cases (one patient with diabetes and metastatic tumors, therefore requiring chemotherapy) [25]. A candida was isolated in 2 cases (one patient with diabetes and metastatic tumors, therefore requiring chemotherapy) [25]. A candida was isolated in 2 cases (one patient with diabetes and metastatic tumors, therefore requiring chemotherapy) [25]. A candida was isolated in 2 cases (one patient with diabetes and metastatic tumors, therefore requiring chemotherapy) [25]. A candida was isolated in 2 cases (one patient with diabetes and metastatic tumors, therefore requiring chemotherapy) [25]. A candida was isolated in 2 cases (one patient with diabetes and metastatic tumors, therefore requiring chemotherapy) [25]. A candida was isolated in 2 cases (one patient with diabetes and metastatic tumors, therefore requiring chemotherapy) [25]. A candida was isolated in 2 cases (one patient with diabetes and metastatic tumors, therefore requiring chemotherapy) [25]. A candida was isolated in 2 cases (one patient with diabetes and metastatic tumors, therefore requiring chemotherapy) [25]. A candida was isolated in 2 cases (one patient with diabetes and metastastic bladder tumor, apart from any chemotherapy and a second patient with no particular history, with a metastatic prostate tumor having developed 5 episodes of UTI during his follow-up, which developed during chemotherapy in a context of febrile neutropenia a three-germ UTI associating Klebsiella pneumoniae, Enterococcus faecalis and Candida albicans). Treatment of these infections is always difficult.

Another major problem which concerns these UTIs in patients with solid tumors but also in the general population is the resistance to antibiotics. A review of the literature by Tenney J, et al. published in 2018 described the most common risk factors for this resistance [26]. The most described risk factor was the previous use of antibiotics but also the long-term use of medical devices, a previous hospitalization, an age over 50 years, recurrent UTI, both male and female sexes, immunosuppression and uncontrolled diabetes. These risk factors are frequently observed in patients with solid tumors. In our study, we identified multi-resistant strains in 26.1% of cases. A significant difference in this rate was noted between a single episode of UTI or recurrent episodes of UTI during follow-up (8.4% versus 70%; p < 0.0001), in the presence or not of medical devices (70% versus 13.9%; p = 0.001) and during or apart from chemotherapy (35.7% versus 6.2%; p = 0.02) and there is no significant difference between men and women (p = 0.48) according to data from the literature.

An additional risk factor was identified which is the tumor site (36.2% for pelvic tumors versus 6.2% for extra-pelvic tumors; p = 0.035) which can be referred to the recurrent nature of UTIs in pelvic tumors. Otherwise, we did not note any significant difference according to age < or > of 50 years (p = 0.62).

**Conclusion**

The management of UTIs in patients with solid tumors is complex. The risk factors favoring these infections are multiple and often associated. The presence or not of deficiencies in the host’s immune system as well as the nature of the germ(s) identified and their sensitivity to antibiotics determine the types of complications likely to develop. It therefore seems necessary, according to this study, to implement recommendations for the treatment and prevention of UTIs in cancer. They must be particularly adapted to the level of risk incurred by these various risk factors. It is very important to know the cause of UTI as well as the gateway to treat it effectively. Urinary tract obstruction is the most common cause.

**References**

1. Rolston KVI (2017) Infections in cancer patients with solid tumors: A review. Infect Dis Ther 6: 69-83.
2. Gudiol C, Aguado JM, Carratala J (2016) Bloodstream infections in patients with solid tumors. Virulence 7: 298-308.
3. Tverdek FP, Rolston KV, Chemaly RF (2012) Antimicrobial stewardship in patients with cancer. Pharmacotherapy 32: 722-734.
4. Gaffer-Gvili A, Fraser A, Paul M, Vidal L, Lawrie TA, et al. (2012) Antibiotic prophylaxis for bacterial infections in afebrile neutropenic patients following chemotherapy. Cochrane Database Syst Rev 1: 004386.
5. Chizuka A, Suda M, Shibata T, Kusumi E, Hori A, et al. (2006) Difference between hematological malignancy and solid tumor research articles published in four major medical journals. Leukemia 20: 1655-1657.
6. Avrithscher EBC, Cooksley CD, Rolston KV, Swint JM, Delclos GL, et al. (2014) Serious postoperative infections following resection of common solid tumors: Outcomes,
costs, and impact of hospital surgical volume. Support Care Cancer 22: 527-535.

7. Tandogdu Z, Wagenlehner FME (2016) Global epidemiology of urinary tract infections. Curr Opin Infect Dis 29: 73-79.

8. Daudon M, Traxer O, Lechevalier E, Saussine C (2008) Épidémiologie des lithiases urinaires. Progrès en Urologie 18: 802-814.

9. Bodey GP, Hersh EM, Valdivieso M, Feid R, Rodriguez V (1975) Effects of cytotoxic and immunosuppressive agents on the immune system. Postgrad Med 58: 67-74.

10. Crawford J, Dale DC, Lyman GH (2004) Chemotherapy-induced neutropenia: Risks, consequences, and new directions for its management. Cancer 100: 228-237.

11. Klastersky J, Paesmans M, Rubenstein EB, Boyer M, Elting L, et al. (2000) The multinational association for supportive care in cancer risk index: A multinational scoring system for identifying low-risk febrile neutropenic cancer patients. J Clin Oncol 18: 3038-3051.

12. Kern WV (2006) Risk assessment and treatment of low-risk patients with febrile neutropenia. Clin Infect Dis 42: 533-540.

13. Virizuela JA, Carratala J, Aguado JM, Vicente D, Salavert M, et al. (2016) Management of infection and febrile neutropenia in patients with solid cancer. J Clin Oncol 18: 557-570.

14. Flowers CR, Seidenfeld J, Bow EJ, Karten C, Gleason C, et al. (2013) Antimicrobial prophylaxis and outpatient management of fever and neutropenia in adults treated for malignancy: American Society of Clinical Oncology clinical practice guideline. J Clin Oncol 31: 794-810.

15. Rolston KV (1999) New trends in patient management: Risk-based therapy for febrile patients with neutropenia. Clin Infect Dis 29: 515-521.

16. Marin M, Gudiol C, Garcia-Vidal C, Ardanuy C, Carratala J (2014) Bloodstream infections in patients with solid tumors: Epidemiology, antibiotic therapy, and outcomes in 528 episodes in a single cancer center. Medicine (Baltimore) 93: 143-149.

17. Delves PJ, Roitt IM (2000) The immune system. First of two parts. N Engl J Med 343: 37-49.

18. Bahu R, Chaftari AM, Hachem RY, Ahrar K, Shomali W, et al. (2013) Nephrostomy tube related pyelonephritis in patients with cancer: Epidemiology, infection rate and risk factors. J Urol 189: 130-135.

19. Benson AD, Taylor ER, Schwartz BF (2011) Metal ureteral stent for benign and malignant ureteral obstruction. J Urol 185: 2217-2222.

20. Goldsmith ZG, Wang AJ, Banez LL, Lipkin ME, Ferrandino MN, et al. (2012) Outcomes of metallic stents for malignant ureteral obstruction. J Urol 188: 851-855.

21. Bodey GP (1975) Infections in cancer patients. Cancer Treat Rev 2: 89-128.

22. Kline KA, Lewis AL (2016) Gram-positive uropathogens, polymicrobial urinary tract infection, and the emerging microbiota of the urinary tract. Microbiol Spectr 4.

23. Ang BS, Telenti A, King B, Steckelberg JM, Wilson WR (1993) Candidemia from a urinary tract source: Microbiological aspects and clinical significance. Clin Infect Dis 17: 662-666.

24. Fisher JF, Chew WH, Shadomy S, Duma RJ, Mayhall CG, et al. (1982) Urinary tract infections due to Candida albicans. Rev Infect Dis 4: 1107-1118.

25. Rolston KV (1999) New trends in patient management: Risk-based therapy for febrile patients with neutropenia. Clin Infect Dis 29: 515-521.