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Immunological signatures of candida-associated urinary tract infections in urolithiasis: Role of interleukins and complement components

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Abstract. *Urinary tract infections (UTIs) are prevalent among individuals with urolithiasis. Bacterial pathogens are commonly associated with UTIs; however, fungal infections are increasingly recognised, particularly in patients with pre-existing urological abnormalities.*

The present cross-sectional study aimed to investigate the relationship between UTIs caused by Candida species (Candida spp.) and selected interleukins (ILs) and complement component 2 (C2) and 4 (C4) in patients with urolithiasis.

Methods. One hundred urine samples were collected from patients with urolithiasis and twenty urine samples from healthy individuals (controls). Candida spp. were detected in 47% of the urine samples from patients (versus none in the control group), based on growth characteristics on Sabouraud dextrose agar (SDA) and staining with Gram stain and lactophenol cotton blue (LPCB). Urine levels of IL-6, IL-17, IL-22, C2, and C4 were measured using commercially available ELISA assay kits.

Results. The most common species was Candida albicans (C. albicans) (59.5%), while the least common was Candida krusei (C. krusei) (6.3%). Levels of IL-6, IL-17 and IL-22 were significantly increased ($P < 0.05$) in urolithiasis patients (19.6 ± 2.4 pg/ml, 77.8 ± 16.34 pg/ml and 93.5 ± 11.9 pg/ml, respectively) compared with the control group (11.5 ± 3.7 pg/ml, 22.5 ± 6.41 pg/ml and 38.6 ± 9.4 pg/ml, respectively). Levels of C2 were significantly reduced ($P < 0.05$) in patients compared with the control group (51.03 ± 9.44 ng/ml vs. 195.21 ± 13.8 ng/ml).

Conclusions. The obtained data indicate that Candida-associated UTIs in patients with urolithiasis are accompanied by a pronounced local immune response and may worsen the course of the underlying disease. Measurement of urinary levels of IL-6, IL-17, IL-22, and C2 may be useful as additional biomarkers of Candida infection and the intensity of the inflammatory process. These markers could potentially improve diagnosis and risk stratification of complications in this patient population.

Keywords: *urinary tract infection, urolithiasis; Candida spp., candidiasis.*

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Імунологічні маркери кандидо-асоційованої інфекції сечової системи у хворих на уролітіаз: роль інтерлейкінів і компонента комплементу

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Резюме. *Інфекції сечової системи (ІСС) є поширеними серед пацієнтів з уролітіазом. Бактеріальні патогени традиційно пов'язані з ІСС, однак грибкові інфекції отримують дедалі більше визнання, особливо у пацієнтів із наявними урологічними порушеннями.*

Метою цього одномоментного дослідження було визначити взаємозв'язок між ІСС, спричиненою Candida (Candida spp.) та концентрацією інтерлейкінів (ІЛ) -6, -17, -22 і компонента комплементу 2 (С2) і 4 (С4) у пацієнтів з уролітіазом.

Методи. У дослідження включено 100 зразків сечі від пацієнтів з уролітіазом та 20 зразків сечі від здорових добровольців (контрольна група). Визначення Candida spp. проводили шляхом посіву на щільне поживне середовище Сабуро (Sabouraud dextrose agar, SDA) з подальшою оцінкою ростових характеристик колоній. Ідентифікацію підтверджували мікроскопією мазків, забарвлених за Грамом та лактофенол-бавовняним синім (lactophenol cotton blue). Концентрацію ІЛ-6, -17, -22, а також компонентів комплементу С2 і С4 у сечі визначали імуноферментним методом за допомогою комерційних наборів згідно з інструкціями виробника.

Результати. Найпоширенішим видом була Candida albicans (C. albicans) (59,5%), а найрідше визначався Candida krusei (C. krusei) (6,3%). Рівні ІЛ-6, -17 та -22 були статистично-значущо підвищеними ($P < 0,05$) у пацієнтів з уролітіазом (19,6 ± 2,4 пг/мл; 77,8 ± 16,34 пг/мл та 93,5 ± 11,9 пг/мл відповідно) порівняно з контрольною групою (11,5 ± 3,7 пг/мл; 22,5 ± 6,41 пг/мл та 38,6 ± 9,4 пг/мл, відповідно). Проте, рівні С2 були достовірно зниженими ($P < 0,05$) у пацієнтів порівняно з контрольною групою (51,03 ± 9,44 нг/мл проти 195,21 ± 13,8 нг/мл).

Висновки. Отримані дані свідчать, що Candida-асоційовані ІСС у пацієнтів з уролітіазом супроводжуються вираженою місцевою імунною відповіддю та можуть погіршувати перебіг основного захворювання. визначення рівнів ІЛ-6, -17, -22 і С2 у сечі може бути корисним уякості додаткових біомаркерів кандидозної інфекції та інтенсивності запального процесу, що потенційно дозволить покращити діагностику та стратифікацію ризику ускладнень у цій категорії хворих.

Ключові слова: *інфекції сечових шляхів, уролітіаз, Candida spp., кандидоз.*

Introduction. Urinary tract infections (UTIs) are among the most common infectious diseases worldwide and may involve the kidneys, bladder, or urethra [1]. Clinically, UTIs are classified as uncomplicated (uUTIs) or complicated (cUTIs) [2]. The ability of uropathogens to adhere to and invade host tissues is mediated by various virulence factors [3–6]. In the presence of predisposing risk factors, even mild or atypical UTIs can progress to severe and life-threatening infections [7].

Urolithiasis is a prevalent urological condition that significantly increases the risk of urinary tract infection and associated morbidity. Globally, approximately 12% of the population is affected by kidney stones, with recurrence rates of 70–81% in men and 47–60% in women [8, 9].

Candida species represent the leading cause of healthcare-associated fungal infections worldwide [10,11]. In healthy individuals, *Candida spp*. exist as harmless commensals on the skin and mucosal surfaces [12]. However, in immunocompromised patients or those with predisposing conditions (e.g., diabetes mellitus, chronic kidney disease, malignancy, or indwelling urinary catheters), these organisms can become opportunistic pathogens and cause urinary candidiasis [13].

Host immune responses to *Candida* are complex and involve both humoral and cellular mechanisms. Effective clearance of *Candida* infections typically requires a predominant T-helper 1 (Th1) response characterized by the production of interferon-γ (IFN-γ), whereas a shift toward a T-helper 2 (Th2) profile, with cytokines such as interleukins (IL)-4 and IL-10, may impair fungal elimination due to their anti-inflammatory effects [14–16]. An exaggerated Th2 response can suppress essential proinflammatory pathways, thereby facilitating persistence of the infection.

The present study aimed to investigate the association between *Candida*-associated UTIs and levels of selected interleukins (IL-6, IL-17, IL-22) and complement components (C2 and C4) in patients with urolithiasis.

Materials and methods. This cross-sectional study was conducted in full accordance with the principles of the Declaration of Helsinki and approved by

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the Ethics Committee of the Institute of Genetic Engineering and Biotechnology for Postgraduate Studies, University of Baghdad, Iraq (Reference No. 30/7289, dated 30 November 2023). Informed consent was obtained from all participants before inclusion in the study.

Sample collection. Between October to December of 2024, a hundred urine samples were collected from urolithiasis patients who visited the Saladin Province teaching hospital. Twenty further urine samples were taken from people who seemed to be in good health to act as controls.

Isolation of Candida species from urine samples. After being incubated at 37°C for 48 hours, all urine samples were cultured on Sabouraud Dextrose Agar supplemented with 0.5 μg/mL chloramphenicol (Himedia, India). The characteristics of the *Candida* colonies, including their shape, ability to form germ tubes, and number of chlamydospores, were used to identify the species. Under 40× and 100× oil immersion magnification, Gram staining and Lactophenol Cotton Blue preparations were used for the microscopic investigation. Carbohydrate fermentation assays provided additional evidence of species difference.

Immune markers. Urine levels of interleukin-6 (IL-6), interleukin-17 (IL-17), interleukin-22 (IL-22), complement component C2 (Sunlong, China), and complement component C3 (Sunlong, China) were measured using commercially available assay kits. The procedures were executed in a meticulous manner in line with the protocols provided by the manufacturers.

Statistical analysis. All data were coded and entered into IBM SPSS Statistics software, version 25.0 (IBM Corp., Armonk, NY, USA). The normality of distribution of continuous variables was assessed using the Shapiro–Wilk test. Since all continuous variables demonstrated a normal distribution, they are presented as mean ± standard deviation (M ± SD).

Comparisons of continuous variables between two independent groups were performed using the independent-samples Student's t-test. Categorical variables are expressed as absolute numbers and percentages (n, %) and were compared using the χ^2 test or Fisher's exact test, as appropriate.

A two-tailed p-value < 0.05 was considered statistically significant for all analyses [17].

Results. *Demographic and clinical characteristics of the study participants*. A total of 100 patients diagnosed with urolithiasis and 20 healthy controls were enrolled in the study. The demographic and clinical characteristics of both groups are summarized in Table 1.

Table 1

Demographic characteristics of the study population

Variables	Patients (n = 100)	Controls (n = 20)	p-value
Age, years			
M ± SD	45.59 ± 11.17	42.45 ± 11.45	0.225
Range	21-66	22-61	
Sex			
Male	77 (77%)	13 (65%)	0.258
Female	23 (23%)	7 (35%)	
BMI, kg/m^2			
M ± SD	27.84 ± 3.03	28.18 ± 3.33	0.358
Range	22.5-36.2	21.8-34.0	
Smoking			
Never	69 (69%)	16 (80%)	0.323
Ex/current smokers	31 (31%)	4 (20%)	
Comorbidities			
Hypertension	14 (14%)	2 (10%)	0.631
Diabetes mellitus	12 (12%)	1 (5%)	0.693
Chronic kidney disease	3 (3%)	0	1.00
Affected side			
Right	45 (42%)		
Left	47 (47%)		
Both	8 (8%)		
Stone size, cm			
M ± SD	3.81 ± 1.57		
Range	1.5-7.0		
Disease duration, years			
M ± SD	4.82 ± 3.11		
Range	1.1-14.5		

Abbreviations: BMI: body mass index, M: mean, SD: standard deviation,

As indicated in Table 1, there was no significant difference (p = 0.225) in the mean age between the sick group (45.59 ± 11.17 years) and the control group (42.45 ± 11.45 years). With 77% of patients being male and 65% of controls being male (p = 0.258), the gender distribution was also similar between the two groups.

There was no significant difference in the body mass index (BMI), with patients averaging 27.84 ± 3.03 kg/m^2 and controls 28.18 ± 3.33 kg/m^2 (p = 0.358). With 31% of patients and 20% of controls being current or past smokers (p = 0.323), there was also no significant difference in smoking habits.

There were no statistically significant differences (p > 0.05) between the groups in terms of comorbid illnesses; however, 14% of patients and 10% of controls had hypertension, 12% had diabetes mellitus, and 5% had chronic kidney disease.

Among the patients surveyed, 8% had stones on both sides of their kidneys, 47% on the left, and 45% on the right. With a range of 1.5-7.0 cm, the average stone size was 3.81 ± 1.57 cm, and the average duration of the disease was 4.82 ± 3.11 years, with a range of 1.1-14.5 years.

Out of the 100 urine samples analyzed, *Candida* species were detected in 47% of cases (47/100) based on colony morphology on Sabouraud Dextrose Agar and confirmed by Gram staining and Lactophenol Cotton Blue staining (Fig. 1).

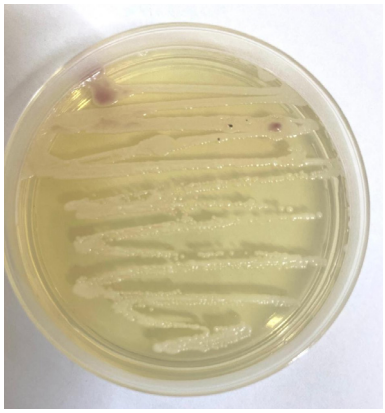

Fig. 1. *Candida* grows in Sabouraud's dextrose agar.

According to growth characteristics and biochemical activity, four species of *Candida* were isolated, as shown in Table 2.

Table 2

Growth characteristics and biochemical activity of Candida species isolated from the urine of patients with urolithiasis

Candida spp	Germ tube formation	Chlamydospores formation	Sugar fermentation				
			Sucrose	Glucose	Maltose	galactose	Trehalose
C. albicans	+	+	-	+	+	+	+
C. tropicalis	-	-	+	+	+	+	+
C.parapsilosis	-	-	-	+	-	-	-
C.Krusei	-	-	-	+	-	+/-	-

Candida albicans was the most prevalent species (28 isolates, 59.5%), whereas *Candida krusei* was the least frequent (3 isolates, 6.3%) (Fig. 2).

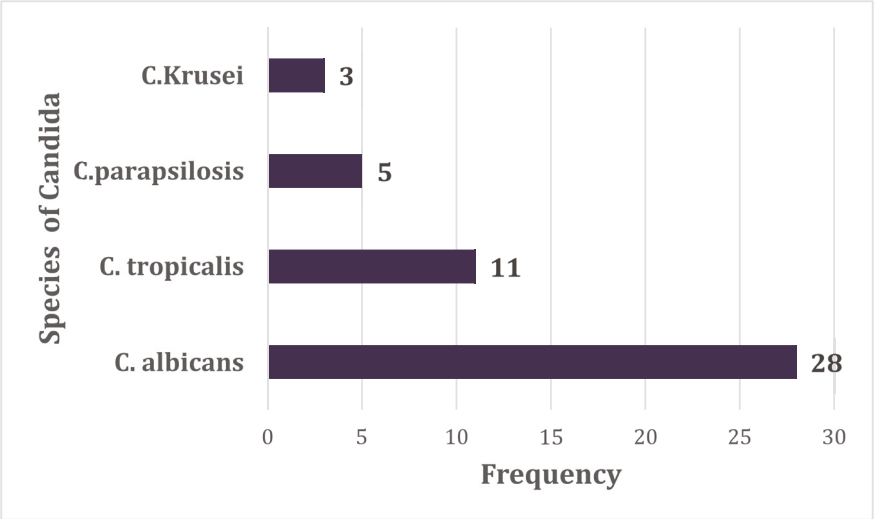

Fig. 2. Distribution of *Candida spp.* isolated from urine samples of patients with urolithiasis.

Urine level of interleukins and complement components. Concentrations of selected interleukins in the research groups are displayed in Table 3.

Table 3

Interleukin concentration in urine from healthy humans and Urolithiasis patients infected with UTI

Interleukins	Patients (n = 100)	Controls (n =2 0)	p-value
IL-6, pg/ml	19.6 ± 2.4	11.5 ± 3.7	0.009
IL-17, pg/ml	77.8 ± 16.34	22.5 ± 6.41	<0.001
IL-22, pg/ml	93.5 ± 11.9	38.6 ± 9.4	<0.001

As presented in Table 3, urinary levels of all studied cytokines (IL-6, IL-17, and IL-22) were significantly higher in patients with urolithiasis compared to healthy controls ($p < 0.001$ for all markers).

Urinary concentrations of complement components C2 and C4 in patients with urolithiasis and healthy controls are presented in Table 4.

Table 4

Urine complement concentrations from healthy humans and Urolithiasis patients infected with UTI

Complement (ng/ml)	Patients (n = 100)	Controls (n = 20)	p-value
C2, ng/ml	51.03 ± 9.44	195.21 ± 13.8	<0.001
C4, ng/ml	138.12 ± 15.06	149.82 ± 11.93	0.451

Patients with urolithiasis exhibited significantly lower urinary C2 levels compared to healthy controls ($p < 0.001$), suggesting possible consumption or impaired production within the classical complement pathway. No significant difference was observed in urinary C4 levels between the two groups ($p = 0.451$).

Discussion. *Candida spp.* were found in 47% of UTI patients in this investigation, indicating a high incidence of fungal involvement. Our findings confirm Altayyar et al. [18] and Ghaddar et al. [19]'s significant *Candida* prevalence in UTI samples. This study found that vaginal swabs isolated *Candida* better than urine samples, similar to Sahal and Bilkay [20]. Mohsin and Ali [21] cultivated samples on SDA, a selective medium that promotes fungal growth, and identified isolates using macroscopic and microscopic methods. SDA is still a standard medium in clinical mycology due to its selectivity for *Candida spp.* and the use of antimicrobials such as cycloheximide and chloramphenicol to reduce bacterial contamination [22]. To confirm the morphological diagnosis, we stained with Lactophenol Cotton Blue (LPCB). Potassium hydroxide (KOH) treatment often produces Candida-like hyphae, pseudohyphae, and budding yeast cells [23-25]. The germ tube test distinguished *Candida albicans* from other non-albicans species [26]. Musa et al. [27] examined urine samples from pregnant women using Chromogenic Agar, an early *Candida* species categorization method based on colony pigmentation. *Candida albicans* (23.52%), krusei (17.66%), dubliniensis (11.76%), tropicalis (5.68%), and glabrata (41.18%) were discovered. Overall positivity was 8.67%. These findings highlight the great variety of *Candida* species and the significance of selective medium and microscopy for urinary tract *Candida* infection detection.

In this study, urolithiasis patients had greater levels of IL-6, IL-17, and IL-22, indicating an enhanced inflammatory and immunological response. This supports Romani et al. [28], who showed that wild-type controls were less vulnerable to systemic candidiasis than IL-6-deficient animals [29]. IL-17, a host defense cytokine, is mostly produced by T-helper 17 (Th17) cells during *Candida* infections. IL-17 induces chemokines to attract and activate macrophages and neutrophils, improving *Candida spp.* phagocytic clearance [30]. IL-17 also induces the synthesis of strong antifungal antimicrobial peptides, including defensins and cathelicidins [31]. Thus, IL-17 production or signaling issues are commonly connected to long-term or systemic *Candida* infections [32].

However, the association between IL-17 expression and neutrophil recruitment appears complex. Yano et al. [33] showed no correlation between vaginal IL-17 levels and early neutrophil migration. Chemotactic proteins from epithelial cells stimulate early neutrophil recruitment after *Candida albicans* exposure, according to studies. Interesting, neutrophil counts increased steadily but IL-17 levels rose slowly throughout resolution. Increased immunological activity can worsen tissues and symptoms in vulvovaginal candidiasis, which is a critical clinical issue because neutrophil infiltration is linked to symptoms [34]. In general, the ILs were applied in different medical fields [35-37], but IL-6, IL-17, and IL-22 levels are considerably greater in urolithiasis patients than in healthy controls, suggesting that inflammatory cytokine activity may rise with severity. An acute inflammation marker, IL-6, may be associated with more severe or symptomatic stone disease, occasionally aggravated by infection [38]. Due to mucosal injury, persistent inflammation, or fungal co-infection,

Th17 cells release more IL-17 and IL-22, indicating an active immune system. In addition to protecting local tissues, these cytokines can aggravate tissue injury, impede healing, and cause stones to recur or develop chronic problems [39]. Thus, their growth may indicate disease severity and prognosis in individuals with infectious or immune-mediated urolithiasis. According to our findings, patients had considerably lower urine complement C2 levels than healthy controls. Heidenreich and Dierich [40] discovered that *Candida albicans* did not change adherence to C2-coated erythrocytes. Recurrent *Candida* infections were related to reduced C2 levels, even if complement C4 levels were not substantially different between the control and patient groups, according to Atallah et al. [41]. C4 concentrations were greater in vulvovaginal candidiasis patients, suggesting that C4 protects against fungal infection [42]. C4 activity, which facilitates leukocyte migration to infection sites, may improve fungal infection clearance. C2 and C4 perform distinct but potentially complementary roles in the host's *Candida* defenses. This study's low C2 levels suggest immunological dysregulation or stone-induced inflammation that consumes complement components, reducing classical complement pathway activation. This dysfunction may impede the immunological response, causing repeated or severe clinical episodes, delayed inflammation resolution, or persistent urinary infections [43]. Even if C4 concentrations remained stable, complement activation imbalance may affect disease duration and progression. These findings show a link between complement dysfunction, notably reduced C2 activity, and disease severity in urolithiasis patients. This research improves our understanding of *Candida*-induced urolithiasis immune responses; however, there are several limitations. The small sample size, especially of the control group (n = 20), limits statistical power and generalizability. Lack of fungal burden quantification and molecular identification methods like PCR may have affected Candida detection sensitivity and species distinction, which suggests employing the molecular techniques in detection, because they were applied in different medical areas [44-47]. Serum cytokine and complement levels were not evaluated simultaneously, which would have helped explain local and systemic immune responses. Uncontrolled variables such as stone composition, comorbidities, and antibiotic treatment may have impacted infection susceptibility and immunological activity.

Conclusions. The present study demonstrates that *Candida albicans* was the predominant species responsible for *Candida*-associated UTIs in patients with urolithiasis, confirming its leading role among *Candida* species in this clinical setting. *Candida*-associated UTIs in patients with urolithiasis are accompanied by a pronounced local immune response and may worsen the course of the underlying disease. Measurement of urinary levels of IL-6, IL-17, IL-22, and C2 may be useful as additional biomarkers of Candida infection and the intensity of the inflammatory process. These markers could potentially improve diagnosis and risk stratification of complications in this patient population.

Conflict of interest. The authors declare that they have no conflicts of interest.

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Data availability statement. The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Authors' contributions. Both authors contributed equally to the development of the research plan, the statistical analysis of the results, and the writing of the manuscript.

References:

1. *Flores-Mireles AL, Walker JN, Caparon M, Hultgren SJ.* Urinary tract infections: Epidemiology, mechanisms of infection and treatment options. Nat Rev Microbiol. 2015;13(5):269–84. doi: 10.1038/nrmicro3432.
2. *Johnson JR.* Definitions of complicated urinary tract infection and pyelonephritis. Clin Infect Dis. 2017;64(3):390. doi: 10.1093/cid/ciw712.
3. *Lewis AJ, Richards AC, Mulvey MA.* Invasion of host cells and tissues by uropathogenic bacteria. Microbiol Spectr. 2016;4(6):359–81. doi: 10.1128/microbiolspec.UTI-0026-2016.
4. *Abdullah MM, AL-Rubaii BA.* Effect of Lactobacillus supernatant on swarming-related gene expression in Proteus mirabilis isolated from urinary tract infections. Ukrainian Journal of Nephrology and Dialysis. 2024;4(84):39-48. doi: 10.31450/ukrjnd.4(84).2024.05.
5. *Ibrahim GJ, Laftaah BA.* The efficiency of certain amino acids in regulating chABCI gene expression in proteus mirabilis. Iraqi J of Science. 2024; 65(9):4983-92. doi: 10.24996/ijs.2024.65.9.15.
6. *Husain AG, Alrubaii BA.* Molecular detection and expression of virulence factor encoding genes of Pseudomonas aeruginosa isolated from clinical samples. Biomedicine. 2023;43(5):1514-9. doi: 10.51248/.v43i5.3263.
7. *Zagaglia C, Ammendolia MG, Maurizi L, Nicoletti M, Longhi C.* Urinary tract infections caused by uropathogenic Escherichia coli strains—new strategies for an old pathogen. Microorganisms. 2022;10(7):1425. doi: 10.3390/microorganisms10071425.
8. *Soundararajan P, Mahesh R, Ramesh T, Begum HV.* Effect of Aerva lanata on calcium oxalate urolithiasis in rats. Indian J Exp Biol. [Internet]. 2006;44:981-6. Available from: https://europepmc.org/article/med/17176671.

9. *Vijaya T, Sathish KM, Ramarao NV, Babu NA, Ramarao N.* Urolithiasis and its causes—short review. J Phytopharmacol. 2013;2(3):1-6. doi: 10.31254/phyto.2013.21309.
10. *Behzadi P, Behzadi E, Ranjbar R.* Urinary tract infections and Candida albicans. Cent Eur J Urol. 2015;68(1):96-101. doi: 10.5173/ceju.2015.01.474.
11. *Mohammed IS, Al-Bayati A, Hashim ST, Saleh TH, Laftaah BA, Hasoon BA.* The effect of zinc oxide on inhibition of Candida albicans isolated from leukemia patients. Microbial Biosystems. 2025;10(2):202-212. doi: 10.21608/mb.2025.366586.1265.
12. *Yapar N.* Epidemiology and risk factors for invasive candidiasis. Ther Clin Risk Manag. 2014;10:95–105. doi: 10.2147/TCRM.S40160.
13. *Bilal H, Shafiq M, Hou B, Islam R, Khan MN, Khan RU, et al.* Distribution and antifungal susceptibility pattern of Candida species from mainland China: a systematic analysis. Virulence. 2022;13(1):1573–89. doi: 10.1080/21505594.2022.2123325.
14. *Ashman RB, Farah CS, Wanasaengsakul S, Hu Y, Pang G, Clancy RL.* Innate versus adaptive immunity in Candida albicans infection. Immunol Cell Biol. 2004;82(2):196–204. doi: 10.1046/j.0818-9641.2004.01217.x.
15. *Ferwerda B, Ferwerda G, Plantinga TS, Willment JA, van Spriel AB, Venselaar H, et al.* Human dectin-1 deficiency and mucocutaneous fungal infections. N Engl J Med. 2009;361(18):1760–7. doi: 10.1056/NEJMoa0901053.
16. *Tuite A, Mullick A, Gros P.* Genetic analysis of innate immunity in resistance to Candida albicans. Genes Immun. 2004;5(8):576–87. doi: 10.1038/sj.gene.6364130.
17. *Othman KI, Shorish MA, Belan A, Mjda M.* Isolation and identification of Candida spp. from urine and antifungal susceptibility test. Iraqi J Sci. [Internet]. 2018;59(4B):1981–8. Available from: https://ijs.uobaghdad.edu.iq/index.php/eijs/article/view/554.
18. *Altayyar IA, Alsanosi AS, Osman NA.* Prevalence of vaginal candidiasis among pregnant women attending different gynecological clinics in South Libya. Eur J Exp Biol. [Internet]. 2016;6(3):25–9. Available from: https://www.primescholars.com/articles/prevalence-of-vaginal-candidiasis-among-pregnant-women-attending-different-gynecological-clinic-at-south-libya.pdf.
19. *Ghaddar N, El Roz A, Ghssein G, Ibrahim JN.* Emergence of vulvovaginal candidiasis among Lebanese pregnant women: prevalence, risk factors, and species distribution. Infect Dis Obstet Gynecol. 2019;2019:1–8. doi: 10.1155/2019/5016810.
20. *Sahal G, Bilkay IS.* Distribution of clinical isolates of Candida spp. and antifungal susceptibility of high biofilm-forming Candida isolates. Rev Soc Bras Med Trop. 2018;51(5):644–50. doi: 10.1590/0037-8682-0136-2018.
21. *Mohsin ZA, Ali WS.* Antagonistic activity of bacteriocin-producing Lactobacillus against Candida spp. Iraqi J Sci. 2021;62(5):2153–62. doi: 10.24996/ijs.2021.62.7.4.
22. *Acharya T, Hare J.* Sabouraud agar and other fungal growth media. Laboratory Protocols in Fungal Biology: Current Methods in Fungal Biology. [Internet]. 2022:69–86. Available from: https://link.springer.com/chapter/10.1007/978-3-030-83749-5_2.
23. *Larone DH.* Medically important fungi: a guide to identification. 5th Edition. Washington, DC: ASM Press; 2011:510 p.
24. *Singh S.* Microbial assay techniques. In: Medical Microbiology. 2022 Apr 4. p. 177.
25. *Thammahong A, Kiatsurayanon C, Edwards SW, Rerknimitr P, Chiewchengchol D.* The clinical significance of fungi in atopic dermatitis. Int J Dermatol. 2020;59(8):926–35. doi: 10.1111/ijd.14941.
26. *Saeed AS, Saadullah AA.* Isolation, identification, and antifungal susceptibility testing of Candida species from dermatologic specimens in Duhok Province. ZANCO J Pure Appl Sci. 2019;31(4):1-8. doi: http://dx.doi.org/10.21271/zjpas
27. *Musa SAM, Magzoub M, Alhassan ASA, Hammad NMA.* Prevalence of Candida spp. isolated from urine samples of pregnant women from Kassala State, Sudan. Am J Microbiol Res. 2020;8(3):79–82. doi: 10.12691/ajmr-8-3-1.
28. *Romani L, Mencacci A, Cenci E, Spaccapelo R, Toniatti C, Puccetti P, et al.* Impaired neutrophil response and CD4+ T helper cell 1 development in interleukin-6-deficient mice infected with Candida albicans. J Exp Med. 1996;183(4):1345–55. doi: 10.1084/jem.183.4.1345.
29. *Van Enckevort FHJ, Netea MG, Hermus ARMM, Sweep CGJ, Meis FGM, Van der Meer JWM, et al.* Increased susceptibility to systemic candidiasis in interleukin-6 deficient mice. Med Mycol. 1999;37(6):419-26. doi: 10.1046/j.1365-280x.1999.00247.x.
30. *Li Z, Lu G, Meng G.* Pathogenic fungal infection in the lung. Front Immunol. 2019;10:1524. doi: 10.3389/fimmu.2019.01524.
31. *Finkina EI, Balandin DV, Ignatova AA, Kanushkina MD, Egorova EA, Voropaev AD, et al.* Antifungal activity, structural stability, and immunomodulatory effects on human immune cells of defensin from the lentil Lens culinaris. Membranes. 2022;12(9):855. doi: 10.3390/membranes12090855.
32. *Tangye SG, Puel A.* The Th17/IL-17 axis and host defense against fungal infections. J Allergy Clin Immunol Pract. 2023;11(6):1624–34. doi: 10.1016/j.jaip.2023.04.015.

33. *Yano J, Kolls J, Happel KI, Wormley F, Wozniak L, Fidel PJ.* The acute neutrophil response mediated by S100 alarmins during vaginal Candida infections is independent of the Th17-pathway. PLoS One. 2012;7(9):e46311. doi: 10.1371/journal.pone.0046311.
34. *Fidel PL.* Immunity in vaginal candidiasis. Curr Opin Infect Dis. 2005;18(1):107–11. doi: 10.1097/01.qco.0000160897.74492.a3.
35. *Khalaf ZA, Al-Bashar SH, Ibrahim TK, Al-Rubaii BAL.* The correlation among IL-37, IL-6, and IL-10 gene expression in patients infected with Helicobacterpylori. East Ukr Med J. 2025;13(1):103-110 doi: 10.21272/eumj.2025;13(1):103-110.
36. *Jawad NK, Numan AT, Ahmed AG, Saleh TH, Al-Rubaii BA.* IL-38 gene expression: A new player in Graves' ophthalmopathy patients in Iraq. Biomedicine. 2023;43(1):210-5. doi: 10.51248/.v43i1.2027.
37. *Jiad AL, Ismael MK, Salih TA, Malik SN, Al-Rubaii BA.* Genotyping and evaluation of interleukin-10 and soluble HLA-G in abortion due to toxoplasmosis and HSV-2 infections. Annals of parasitology. 2022;68(2):385-390. doi: 10.17420/ap6802.444.
38. *Liang D, Liu C, Yang M.* The association between C-reactive protein levels and the risk of kidney stones: a population-based study. BMC Nephrol. 2024;25(1):39. doi: 10.1186/s12882-024-03476-3.
39. *McAleer JP, Kolls JK.* Directing traffic: IL-17 and IL-22 coordinate pulmonary immune defense. Immunol Rev. 2014;260(1):129-44. doi: 10.1111/imr.12183.
40. *Heidenreich F, Dierich MP. Candida albicans* and *Candida stellatoidea*, in contrast to other *Candida* species, bind iC3b and C3d but not C3b. Infect Immun. 1985;50(2):598–600. doi: 10.1128/iai.50.2.598-600.1985.
41. *Atallah RB, Osama AH, Hesham SA, Hagar Ali MA.* Assessment of complement (C2 & C4) in patients with recurrent candidal infections. Egypt J Hosp Med. 2019;74(5):994–1002. doi:10.21608/ejhm.2019.25812.
42. *Amna NJ, Hadeel AM, Kalid AH.* Estimation of immunoglobulins and complements and using enzyme-linked immunosorbent assay in identification of vulvovaginal candidiasis. Baghdad Sci J. 2009;6(3):427–31. doi: 10.21123/bsj.2009.6.3.427-431.
43. *Dunkelberger J, Song WC.* Complement and its role in innate and adaptive immune responses. Cell Res. 2010;20:34–50. doi: 10.1038/cr.2009.139.
44. *Jassim TS, Al-Fendi AM, Hashim ST, Saleh TH, Al-Rubaii BA.* Molecular detection of Rubella virus (1E genotype) in clinical sample of pregnant women, and it's related to abortion. Reproductive health of woman. [Internet]. 2025;23(3):113-8. Available from: http://nbuv.gov.ua/UJRN/rzzh_2025_3_17.
45. *Jassim TS, Talib SS, Jaber NR, Sahib DH, Ali RW, Al-Rubaii B.* Impact of hepatitis C virus on IFITM3 gene expression: A comprehensive analysis incorporating serological detection and viral load quantification via qPCR. Polymers in Medicine. 2025;55(1):21-30. doi: 10.17219/pim/199333.
46. *Husain AG, Alrubaii BA.* Molecular detection and expression of virulence factor encoding genes of Pseudomonas aeruginosa isolated from clinical samples. Biomedicine. 2023;43(5):1514-9. doi: 10.51248/.v43i5.3263.
47. *Al-Rubii BA.* Cloning LasB gene of Pseudomonas aeruginosa elastase 10104-2aI in E. coli BL21 and E. coli DH5α and investigated their effect on the stripping of Vero cells. Pakistan J Biotechnol. [Internet]. 2017;14(4):697-705. Available from: https://www.researchgate.net/publication/322303302_Cloning_LasB_gene_of_pseudomonas_aeruginosa_eiastase_10104-2aI_in_E_coli_BL21_and_e_coli_DH5_and_investigated_their_effect_on_the_stripping_of_vero_cells.