

Original Article

The Association Between Asymptomatic Bacteriuria and Any Specific Uropathogen with Renal Function and Glomerular Filtration Rate in Women of Reproductive and Postmenopausal Age: A Preliminary Study

Mehrdad Haghghi¹, Fatemeh Behrouzmanesh², Mehdi Goudarzi^{2*}

¹Infectious Diseases and Tropical Medicine Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran

²Department of Microbiology, Shahid Beheshti University of Medical Sciences, School of Medicine, Tehran, Iran

Received: 6 October, 2025; Accepted: 29 November, 2025

DOI: 10.22037/nbm.v14i1.50551

Abstract

Background: In this study, we examine the association between renal function and asymptomatic bacteriuria in women of reproductive and Postmenopausal age.

Materials and Methods: This cross-sectional study was performed during 2 years (2022-2023) in Tehran, Iran. One hundred eighty-eight women of reproductive and Postmenopausal age with and without asymptomatic bacteriuria were enrolled in our study. The estimated glomerular filtration rate of all participants was evaluated. The association between reduced estimated glomerular filtration rate and asymptomatic bacteriuria was assessed, and the correlation between specific uropathogens and estimated glomerular filtration rate was analysed accordingly.

Results: The mean level of creatinine in all culture-positive samples (including *E. coli* and non-*E. coli* positive samples) was 0.85 mg/dl. At the same time, it was 0.77 mg/dL in culture-negative samples (P value < 0.05). The mean eGFR was 84.65 mL/min/1.73 m² and 101.06 mL/min/1.73 m² in culture-positive and culture-negative urine samples, respectively (P value < 0.05).

Conclusion: The estimated glomerular filtration rate was significantly lower in the culture-positive group, indicating a meaningful correlation between estimated glomerular filtration rate and asymptomatic bacteriuria. The blood urea nitrogen levels, however, were almost equal across the two culture result groups, indicating no meaningful correlation between blood urea nitrogen and asymptomatic bacteriuria. When comparing the etiologies of infection (*E. coli* vs. other bacterial culprits), there was no significant difference in estimated glomerular filtration rate between culture-positive patients.

Keywords: Asymptomatic bacteriuria, Uropathogen, Renal function

*Corresponding Author: Mehdi Goudarzi, Department of Microbiology, Shahid Beheshti University of Medical Sciences, School of Medicine, Tehran, Iran. Email: goudarzim@yahoo.com

Please cite this article as: Haghghi M, Behrouzmanesh F, Goudarzi M. The Association Between Asymptomatic Bacteriuria and Any Specific Uropathogen with Renal Function and Glomerular Filtration Rate in Women of Reproductive and Postmenopausal Age: A Preliminary Study. Novel Biomed. 2026;14(1):36-40.

Introduction

Chronic kidney diseases (CKD) are a global public

health problem with a high burden of disease that is largely preventable and also treatable. CKD, or chronic kidney disease (CRF), is a term that encompasses all degrees of decreased kidney function^{1,2}. Considering

the high burden of CKD in many regions of the world and the consequences of this disorder on different aspects of human health, evaluating high-risk populations and treating CKD patients is of great importance. Diabetes is the leading cause of CKD^{1,3,4}. High blood pressure, heart (cardiovascular) disease, smoking, and obesity are among other risk factors that can increase the chance of developing chronic kidney disease. Immune function may be impaired in patients with end-stage renal failure. Given the immune system's fundamental role in preventing infection, CKD patients may be more prone to acute bacterial and viral infections. Much evidence shows that infection is a frequent event in patients with renal failure and in CKD. Reduced estimated glomerular filtration rate (eGFR), a hallmark of renal failure, is associated with a higher risk of subsequent infections and mortality^{3,5,6}. Some studies have suggested that CKD is a risk factor for non-cardiovascular morbidity and mortality, including that caused by infection, and have investigated associations between CKD and specific infectious conditions. Infection is a frequent event in patients with non-dialysis advanced CKD patients¹. Infection events in patients receiving dialysis not only contribute to a higher risk of death but are also associated with substantial morbidity. Those who have reduced kidney function are found to be at greater risk for all-cause infection-related hospitalization⁷.

In a study of 25,675 participants from a single Canadian health region, individuals with eGFRs of less than 30 mL/min/1.73 m² were found to have a 3.5-fold higher risk of bloodstream infection and more than 4-fold higher risk of subsequent 30-day mortality compared with those with eGFRs of 60 mL/min/1.73m² or higher⁸. The innate immune system in the urinary tract expresses a range of pattern recognition receptors, enabling early recognition of pathogens and playing an essential role in preventing infection. When uropathogens invade the urinary tract, innate immune cells initiate signaling cascades that trigger a local immune response and ultimately prevent infection^{7,8}.

Innate immune effectors are activated during CKD, but their antibacterial capacity is impaired, leading to increased susceptibility to extracellular bacterial infections⁶. CKD patients also exhibit profound

alterations in cellular and humoral adaptive immune responses, which increase the risk of malignancies and viral infections³⁻⁶. Considering the above-mentioned facts, it is probable that chronic kidney disease can affect the functioning of the innate and adaptive immune systems in the urinary tract, increasing vulnerability to asymptomatic bacteriuria and perhaps frank urinary tract infection (UTI). Elevated creatinine levels and declining eGFR (without renal failure) may also predispose patients to infectious diseases.

Methods

2.1. Study Design and Setting

In a period of 2 years (2022-2023), 188 women of reproductive and postmenopausal age (age above 15) with and without asymptomatic bacteriuria were enrolled in our study. All participants had no signs or symptoms of urinary tract infection. Negaresh Pathobiology Laboratory was the reference laboratory. The exclusion criteria were as follows: 1) use of any antibacterial agent within the last 3 months 2) use of any nephrotoxic medicine 3) nephrolithiasis 4) history of surgical procedure in urinary tract within the last 3 months 5) presence of indwelling urinary catheters 6) pregnancy 7) gynecological disorders 8) urinary tract stent or nephrostomy tube and 9) symptomatic patients. Clean voided midstream urine samples were processed within 2 hours of collection. Samples were considered positive if they contained $\geq 10^5$ CFU of the urinary pathogen/ml of pure culture⁹. Blood agar, MacConkey agar, and Eosin methylene blue plates were used for pathogen identification and differentiation.

Blood urea nitrogen (BUN), creatinine, and eGFR of all participants were evaluated and analysed accordingly. Normal GFR varies with age, sex, and body size and declines with age. The National Kidney Foundation recommends using the CKD-EPI Creatinine Equation (2021) to estimate GFR.

2.2. Definition

Bacteriuria was defined as the presence of a significant colony-forming unit (CFU) of bacteria (more than 10⁵) cultured from appropriately collected urine samples⁹. CKD is defined as abnormalities in kidney function or structure that persist for more than 3 months. The definition of CKD includes all individuals with markers

of kidney damage or an eGFR of less than 60 mL/min/1.73 m² on at least two occasions, 90 days apart^{1-4,6}.

Results

A total of 450 medical records were evaluated in our assay. After excluding documents with missing data and other exclusion criteria, 188 women with and without asymptomatic bacteriuria were enrolled in the study. We evaluated renal function and glomerular filtration rate in positive and negative urine samples and also analyzed the association between specific uropathogens and eGFR in patients with asymptomatic bacteriuria.

All study participants were female. The mean age of the women participating in our study was 49 years, with a maximum age of 91 and a minimum of 16. The mean age of women with positive urine cultures was 59, and it was 40 for those with negative urine cultures. Eighty-four urine samples yielded positive cultures, while the remaining 104 had negative cultures. *E. coli* was found to be the major pathogen among the positive urine cultures and accounted for 75% of infections. *Klebsiella pneumoniae* was the second-most common pathogen isolated from urine samples, accounting for 16 percent of infections. The remaining uropathogens included *Staphylococcus saprophyticus*, *Enterococcus*, and *Enterobacter*, accounting for 8 percent of infections. The mean creatinine level of all participants was 0.80 mg/dL, with maximum and minimum levels of 2.22 mg/dL and 0.52 mg/dL, respectively. Also, the mean BUN level of all participants was 31.60 mg/dL, with maximum and minimum levels of 62 mg/dL and 19 mg/dL, respectively.

The mean creatinine level in all culture-positive samples (including *E. coli*- and non-*E. coli*-positive samples) was 0.85 mg/dL. In comparison, it was 0.77 mg/dL in culture-negative samples (P value < .05). Figure 1 demonstrates the distribution of creatinine by culture result. Also, the mean BUN level was 32.15 in culture-positive samples and 31.15 in culture-negative samples (P value = 0.19). Figure 2 demonstrates the distribution of BUN by culture result. The mean eGFR level of all participants was 93.73 mL/min/1.73 m², with maximum and minimum levels of 132

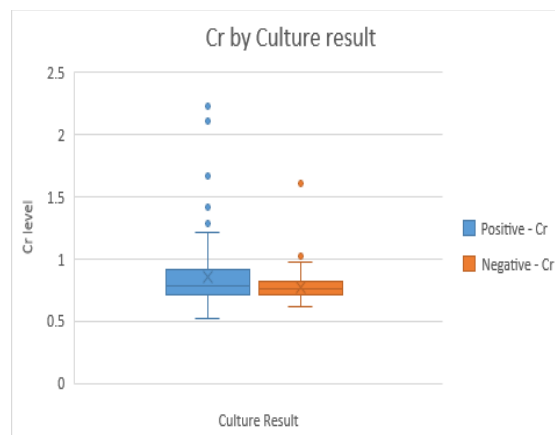


Figure 1. The distribution of creatinine by culture result.

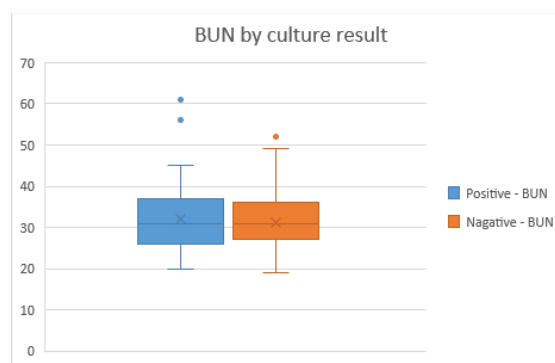


Figure 2. The distribution of BUN by culture result.

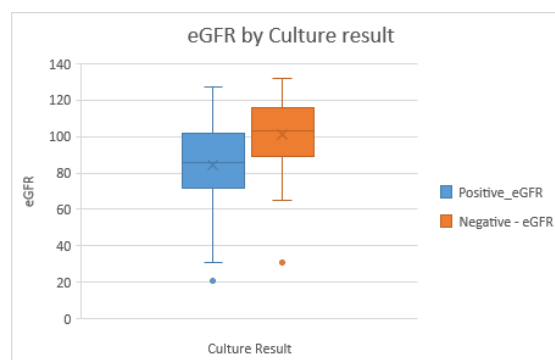


Figure 3. Distribution of eGFR by Culture results.

mL/min/1.73 m² and 21 mL/min/1.73 m², respectively. The mean eGFR was 84.65 mL/min/1.73 m² and 101.06 mL/min/1.73 m² in culture-positive and culture-negative urine samples, respectively. (P value < .05) Figure 3 demonstrates the distribution of eGFR by culture result. The mean eGFR level was 90.71 and 89.86 in *E. coli* and Non-*E. coli* positive urine culture, respectively (P value = 0.13). Figure 4 shows the eGFR distribution for positive cultures.

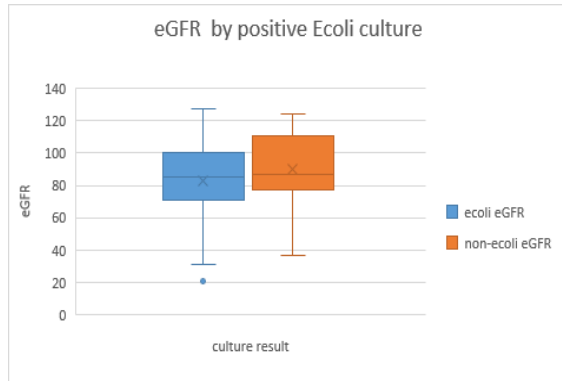


Figure 4. eGFR distribution by positive culture.

Discussion

The impact of renal function on the immune system's defense mechanisms against infectious diseases is a challenging issue that has been debated for many years. Impaired immune response in patients with CKD leads to increased incidence and severity of microbial infections^{1,3,4,10-12}. Elevated creatinine levels and declining eGFR (without renal failure) may also predispose patients to infectious diseases. Given that asymptomatic bacteriuria can progress to frank UTI, eliminating risk factors for asymptomatic bacteriuria may lower the risk of developing UTI^{8,12-14}.

We evaluated the association between renal function, glomerular filtration rate, and asymptomatic bacteriuria in women of reproductive and Postmenopausal age. We also assessed the association between any specific uropathogen and eGFR in the study population with positive cultures. Given the potential progression of asymptomatic bacteriuria to a frank urinary tract infection (UTI), eliminating risk factors for asymptomatic bacteriuria may lower the risk of developing UTI. Renal failure and CKD may predispose patients to a range of infections, specifically urinary tract infections. A national population-based cohort study of 62,872 patients with advanced CKD revealed that approximately one-third of the patients experienced at least one infection event before transitioning to permanent dialysis⁷.

The association between glomerular filtration rate and infectious diseases may be related to the effect of renal function on the immune system's response to infectious pathogens. CKD is associated with a complex defect of almost all components of the

immune system, resulting in a peculiar state of “chronic inflammatory immune depression” named CKD-associated immune dysfunctions^{6,15-17}.

Based on previous studies, chronic renal failure is a risk factor for the development of urinary infections due to metabolic disorders that result in secondary immunodeficiency, affecting all components of immunity^{14,18,19}.

Owing to immune deficiency in patients with CKD, opportunistic infections such as fungal infections, *Pneumocystis jiroveci*, and viral infections are more common than in the general population^{6,7}. In research that addressed the association of chronic kidney disease and risk of death from infection, the authors concluded that reduced eGFR and albuminuria were each associated with an increased risk for infection-related mortality in this general population sample of US adults¹. In this study, infection-related mortality rates were higher among participants with higher baseline albumin-to-creatinine ratio (ACR) levels. Higher ACR was associated with increased hazard ratios for infection-related mortality after adjustment for age, race/ethnicity, and sex^{7,16-18}.

In another study evaluating chronic kidney disease as a risk factor for acute community-acquired infections in high-income countries, the authors concluded that predialysis kidney disease is associated with an increased risk of severe infection⁴. The epidemiology of acute Infections among Patients with Chronic Kidney Disease was evaluated in another study by Lorient S et al., which found that acute infections occur more frequently in patients with kidney disease and are associated with poorer outcomes than in the general population¹⁶.

Few epidemiologic reports have addressed the risk of infections in patients with CKD not treated with dialysis. One of these studies reported that Older adults with chronic kidney disease not being treated with dialysis are at increased risk of bloodstream infection and of death following community-onset bloodstream infection². It is probable that elevated creatinine level and decreasing eGFR (without renal failure) may also play a role in predisposing patients to infectious diseases.

Conclusion

The observed eGFR was significantly lower in the

culture-positive group, indicating a meaningful correlation between eGFR and asymptomatic bacteriuria.

Moreover, creatinine levels were significantly higher in the culture-positive group than in the culture-negative group. This was expected as creatinine is used in the eGFR calculation. Higher creatinine levels correlate with lower eGFR; therefore, in the positive culture group, the mean creatinine was significantly higher, and the mean eGFR was significantly lower. The BUN levels, however, were almost equal across the two culture result groups, indicating no meaningful correlation between BUN and asymptomatic bacteriuria. When comparing the etiologies of infection (*E. coli* vs. other bacterial culprits), no significant difference in eGFR was observed between culture-positive patients.

Acknowledgment

None.

Funding

None.

Conflict of interest

The authors further declare that they have no conflict of interest.

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