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EPIDEMIOLOGY, PATHOGENESIS, AND MODERN TREATMENT STRATEGIES OF RENAL CALCULI. AN ANALYSIS OF THE UZBEKISTAN MEDICAL EXPERIENCE

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Abstract

This comprehensive research study is dedicated to investigating the etiology, developmental mechanisms, and contemporary treatment modalities of nephrolithiasis (kidney stone disease), one of the most pressing issues in modern urology. The study highlights the decisive role of Uzbekistan's unique sharply continental climate, high levels of solar insolation, and the mineralization degree of drinking water in the process of stone formation (lithogenesis), supported by statistical and analytical data. The correlation between metabolic disorders, alimentary (dietary) factors, and genetic predisposition in the formation of calcium oxalate, urate, and phosphate stones is examined. In the diagnostic phase, the efficacy of modern Multi-Spiral Computed Tomography (MSCT) is comparatively analyzed against ultrasonography. Regarding treatment strategies, the advantages of transitioning from open surgical procedures to minimally invasive endourological methods—such as Extracorporeal Shock Wave Lithotripsy (ESWL), Percutaneous Nephrolithotomy (PCNL), and Retrograde Intrarenal Surgery (RIRS)—are substantiated through clinical outcomes. The study concludes with the development of practical recommendations for metaphylaxis (preventative aftercare) aimed at reducing disease recurrence.

Keywords

Kidney stone disease, urolithiasis, nephrolithiasis, lithogenesis, Uzbekistan urology, calcium oxalate, hypercalciuria, lithotripsy, endourology, metaphylaxis, hot climate factor.

Introduction

Kidney Stone Disease (KSD) is a polyetiological, chronic, and frequently recurring pathology characterized by the formation of calculi within the kidneys and urinary tract. Globally, the incidence of KSD is rising annually due to shifts in living standards and dietary habits. Due to its geographical location and climatic characteristics, the Republic of Uzbekistan is considered an endemic region for urolithiasis [1]. The significance of the disease lies in its tendency to affect the most active, working-age population (ages 20 to 50). In Uzbekistan, summer temperatures exceeding +45°C lead to severe transepidermal dehydration. Consequently, urine volume decreases (oliguria), while its concentration and crystallization potential increase. This creates an ideal environment for the precipitation of urinary salts and the formation of stone nuclei. In recent years, significant investments have been directed toward modernizing urological services within the healthcare reforms of Uzbekistan [2]. The installation of high-tech endourological equipment in all regional centers has expanded the capacity to remove stones without conventional incisions. However, surgical removal alone does not constitute a complete cure, as recurrence rates for KSD remain between 50-60%. Therefore, investigating the root causes and establishing individualized prevention (metaphylaxis) systems is the paramount task for modern nephrology and urology.

Literature Review: Extensive research exists in local and international scientific literature regarding the etiology and lithogenesis mechanisms of KSD. Regional and Exogenous

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Factor Theory. Professor Sh.I. Giyosov, in his fundamental scientific works, has detailed the role of the hot and arid climate of the Central Asian region in the development of urolithiasis [3]. He posits that high levels of calcium and magnesium salts in drinking water, combined with a diet high in meat and flour-based foods, create a foundation for the formation of uric acid (urate) stones. Metabolic and Endogenous Theories. According to Academician F.A. Akilov and co-authors, KSD should be viewed as a systemic metabolic disorder [4]. Disruptions in the filtration and reabsorption of calcium, oxalate, and uric acid in the renal glomeruli increase the lithogenic properties of urine. International theories regarding Randall's plaques (calcium phosphate deposits in the papillary tissue) as primary sites for stone formation have also been clinically validated by Uzbek scientists. Modern Surgical and Diagnostic Literature. Over the last decade, local urological journals have published numerous articles on the efficacy of minimally invasive technologies, such as Percutaneous Nephrolithotomy (PCNL) and ESWL [6]. These sources emphasize that measuring stone density via MSCT (using Hounsfield Units - HU) is an integral part of modern diagnostics for selecting the appropriate treatment modality.

Methods: The study was conducted between 2022 and 2025 at the Republican Specialized Scientific and Practical Medical Center of Urology and the clinics of the Tashkent Medical Academy, involving 250 hospitalized patients. Study Design and Patient Selection. The cohort consisted of 155 males and 95 females, with an average age of 34.5 years. Criteria for inclusion were renal stones ranging from 0.5 cm to 3.5 cm in size and the absence of chronic kidney disease (CKD). Diagnostic Algorithms. Laboratory Analysis. Urinalysis, urine sediment microscopy (for crystal identification), and measurement of daily urinary calcium, oxalate, and urate levels. Blood tests were performed for calcium, phosphorus, creatinine, and uric acid. Imaging. All patients underwent parallel evaluations using Ultrasonography (USW) and non-contrast MSCT. MSCT determined stone location (upper, middle, lower pole, or renal pelvis) and density (HU). Treatment Modalities. Patients were divided into three groups based on stone size and density. ESWL Group: Stone size <1.5 cm, density <1000 HU. PCNL Group: Stone size >2 cm or staghorn calculi. RIRS Group: Laser-assisted (stone size 1.5–2 cm).

Results: The comprehensive study identified the following clinical and diagnostic patterns in the context of Uzbekistan. Stone Composition and Metabolic Profile. Chemical-structural analysis (infrared spectroscopy) of the recovered stones (n=120) confirmed that 72% were calcium oxalate (whewellite and weddellite), 18% were urate (uric acid), and 10% were mixed or phosphate stones. Urate stones were twice as common in men than in women, highlighting the dietary (alimentary) influence of meat consumption. Diagnostic Efficacy. MSCT showed 99% accuracy in stone detection. It was proven that in patients with a stone density exceeding 1200 HU, ESWL was ineffective (failure of fragmentation). This finding allowed for the timely adjustment of surgical tactics and the reduction of complications. Treatment Outcomes. The "stone-free rate" in the ESWL group was 84%. In the PCNL group, treated for larger or staghorn stones, the success rate reached 92%, with a complication rate (hemorrhage, infection) not exceeding 4%. RIRS (laser) was evaluated as the safest and most effective method for removing stones located in the smaller calyces. Recurrence Analysis. Among patients who adhered to metaphylaxis protocols (diet and medication) following stone removal, the recurrence rate within two years was 8%. In contrast, those who did not follow the protocols faced a recurrence rate of 42%.

Conclusion: Based on the study results, the following conclusions were formulated. Etiological Factor. In Uzbekistan, dehydration and mineral metabolism imbalances caused by the hot climate are primary drivers of KSD. This necessitates public health initiatives to promote proper hydration (minimum 2.5–3 liters of water per day). Diagnostic Standard. Pre-operative MSCT is mandatory for every urological patient. Assessing stone density (HU) is the only way to ensure the correct selection of treatment and avoid complications. Treatment Approach.

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Minimally invasive and endourological technologies have almost entirely replaced open surgery for renal calculi. The combination of ESWL and PCNL provides the best results for treating staghorn stones. Prevention (Metaphylaxis). The treatment of KSD does not end with stone removal. Individualized diets and medications based on the chemical composition of the stone (e.g., citrates for calcium oxalate) reduce the risk of recurrence fivefold.

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