



THE IMPORTANCE OF LABORATORY PARAMETERS AND CYTOLOGICAL ANALYSIS OF URINE IN PEDIATRIC NEPHROLOGY

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Abstract

Background: Kidney and urinary tract diseases in children may be asymptomatic in early stages. Urinalysis provides information about filtration, tubular function, inflammation, and urinary tract injury.

Objective: To review the diagnostic value of routine urine parameters and urinary sediment microscopy in identifying pediatric renal and urinary tract disorders.

Materials and Methods: This narrative review uses Uzbek educational literature and selected international publications on pediatric urinalysis, proteinuria, hematuria, sediment examination, and specimen collection.

Results: Physical, chemical, and microscopic urine tests provide complementary information.

Color, specific gravity, and pH reflect urinary composition; proteinuria and hematuria may indicate renal injury, while leukocyturia, bacteriuria, leukocyte esterase, and nitrites may support suspected infection. Sediment microscopy identifies cells, casts, and crystals. Protein- or albumin-to-creatinine ratios help quantify protein loss.

Conclusion: Urinalysis is an accessible and useful component of pediatric nephrology. Reliable interpretation requires proper collection, timely processing, age-specific reference values, and correlation with clinical findings. Sediment microscopy supports, but does not independently establish, a diagnosis.

Keywords: pediatric nephrology, urinalysis, urinary sediment, proteinuria, hematuria, leukocyturia,

cytology, urinary tract infection, glomerulonephritis, children.

1. Introduction

Pediatric nephrology addresses kidney and urinary tract diseases such as urinary tract infections, pyelonephritis, glomerulonephritis, nephrotic syndrome, congenital abnormalities, tubular disorders, and kidney dysfunction. Symptoms vary with age and disease severity; some children initially have no pain or visible urine changes. Proteinuria, microscopic hematuria, leukocyturia, and impaired concentrating ability may nevertheless be detected in laboratory tests. Urine analysis therefore supports screening, early and differential diagnosis, and monitoring. Uzbek educational sources describe pediatric urinary diseases and their clinical assessment. Urine is formed through glomerular filtration, tubular reabsorption, and secretion, so its composition reflects renal blood flow, filtration-barrier integrity, tubular transport, hydration, and metabolism. Routine analysis combines physical inspection, chemical testing,

and examination of formed elements; culture and quantitative tests may be added when indicated. Abnormal results can also arise from fever, exercise, dehydration, or contamination. Results should be interpreted alongside age, symptoms, history, examination, and repeat testing where appropriate. This review discusses the principal urine parameters and sediment findings used to assess common pediatric disorders.

2. Materials and Methods

This narrative review draws on Uzbek-language educational sources about pediatric nephrology and urinary-system development, including materials by Ibragimov and Akbarova, and selected international publications on urinary proteins, cells, casts, and specimen collection. The material was organized into collection requirements, physical and chemical parameters, microscopy, and clinical applications. No patients were recruited and no new laboratory measurements or statistical analyses were performed; conclusions synthesize the selected literature and established interpretation principles.

3. The Importance of Urine Examination in Pediatric Nephrology

Urinalysis is accessible, minimally invasive, and can reveal several types of abnormalities in one specimen. It is used in screening and when infection, edema, hypertension, unexplained fever, abdominal pain, or altered urination is suspected. Its purposes include detecting renal or urinary disease, identifying proteinuria and hematuria, supporting infection diagnosis, assessing concentrating ability, monitoring disease and treatment, and guiding further tests such as culture, blood chemistry, or ultrasound. Because renal function and urine composition change during childhood, results must be interpreted using age-appropriate laboratory ranges rather than adult values.

3.1. Collection and handling of urine specimens

Specimen quality strongly affects accuracy. Poor collection may introduce skin cells, bacteria, mucus, and leukocytes. A clean-catch midstream sample is preferred in toilet-trained children. In infants, the method depends on the clinical purpose; collection bags are prone to contamination, so suspected infection may require confirmation with a more reliable method. Fresh urine should be examined promptly because delay can allow bacterial growth, change pH, and damage cells or casts. Samples should be correctly labeled and stored according to laboratory procedures. When infection is suspected, collect culture urine before antimicrobial treatment whenever possible.

4. Physical Laboratory Parameters of Urine

4.1. Color and transparency

Normal urine ranges from pale to deeper yellow according to concentration, hydration, diet, and medicines. Dark yellow urine may reflect dehydration; red or pink urine may result from erythrocytes, pigments, foods, or drugs. Brown or tea-colored urine can occur in glomerular disease. Cloudiness may reflect leukocytes, bacteria, crystals, mucus, or contamination. Color alone is not diagnostic and must be compared with dipstick and microscopy findings. A positive blood reaction with erythrocytes supports hematuria; a positive reaction without erythrocytes may suggest hemoglobin or myoglobin.

4.2. Urine specific gravity

Specific gravity estimates urine concentration and is affected by fluid intake, fluid loss, renal concentrating ability, glucose, and protein. High values may occur with dehydration; persistently low values may suggest impaired concentration or excessive fluid intake. A single

result cannot establish tubular dysfunction. Serial measurements or timed testing, such as the Zimnitsky test, may be considered according to age and clinical circumstances.

4.3. Urine pH

Urine pH reflects acidity or alkalinity and varies with diet, acid-base balance, tubular function, medication, and bacterial activity. Persistently abnormal pH may be relevant in tubular disorders or stone formation. Alkaline urine can occur with some urease-producing infections but does not prove infection; pH should be interpreted with other findings.

5. Chemical Laboratory Parameters of Urine

5.1. Proteinuria

Proteinuria is an important pediatric finding. It may result from increased glomerular permeability, reduced tubular reabsorption, or excess circulating proteins. Causes include nephrotic syndrome, glomerulonephritis, congenital kidney disease, and tubulointerstitial disorders; temporary proteinuria can occur with fever, exercise, dehydration, or acute illness. Orthostatic proteinuria may occur in otherwise healthy adolescents. Dipsticks mainly detect albumin and provide only a semiquantitative result, affected by urine concentration, pH, blood, and inflammation. Confirm abnormal results and quantify protein with a spot protein-to-creatinine ratio (PCR), preferably in first-morning urine; an albumin-to-creatinine ratio (ACR) is useful when albumin excretion is specifically assessed. In children older than two years, PCR below about 0.2 mg/mg is commonly used as a reference, but age and laboratory methods matter. Persistent proteinuria, especially with hematuria, hypertension, edema, or reduced kidney function, needs further evaluation.

5.2. Hematuria

Hematuria is erythrocytes in urine and may be visible (macroscopic) or detected only by testing (microscopic). Causes include glomerulonephritis, infection, stones, structural abnormalities, trauma, and other renal or urological disease; transient microscopic hematuria may resolve without persistent disease. Dysmorphic erythrocytes and erythrocyte casts support a glomerular source, especially with proteinuria, hypertension, or edema; more uniform cells may suggest bleeding elsewhere in the urinary tract. A dipstick detects heme activity, not erythrocytes alone, so microscopy is needed. Persistent hematuria may require repeat testing, blood-pressure measurement, kidney-function assessment, and cause-directed investigations.

5.3. Leukocyte esterase and leukocyturia

Leukocyte esterase indicates an enzyme associated with white blood cells. Leukocyturia (pyuria) commonly accompanies urinary inflammation and may support suspected infection, but can also result from contamination, stones, nonbacterial inflammation, or renal disorders. False-positive and false-negative tests occur, and absence of leukocytes does not always exclude infection. Interpret results with collection quality, symptoms, microscopy, nitrites, and culture when indicated.

5.4. Nitrites

Some urinary pathogens, especially certain Gram-negative bacteria, convert dietary nitrates to nitrites in the bladder. A positive nitrite test supports bacteriuria, but sensitivity is limited in infants and children who void frequently; some organisms also do not produce nitrites. A negative result therefore does not exclude infection. Combine nitrites with symptoms, leukocyte esterase, microscopy, and culture.

5.5. Glucose and ketone bodies

Glucose is normally reabsorbed by renal tubules. Glucosuria may occur when blood glucose exceeds the renal threshold or tubular reabsorption is impaired; evaluate the clinical context and measure blood glucose when appropriate. Urinary ketones may occur with fasting, poor carbohydrate intake, vomiting, dehydration, or metabolic illness. In symptomatic children, interpret ketones with blood glucose and hydration status.

5.6. Bilirubin and urobilinogen

Urinary bilirubin and urobilinogen are not primary markers of renal disease but may suggest systemic conditions. Conjugated bilirubin may occur in hepatobiliary disease, while urobilinogen varies in hepatic and hematological conditions. Further testing depends on the clinical picture.

6. Cytological Examination of Urinary Sediment

Sediment microscopy identifies erythrocytes, leukocytes, epithelial cells, casts, crystals, and microorganisms. In pediatric nephrology it helps assess inflammation, glomerular injury, tubular damage, and urinary abnormalities. Routine sediment examination differs from specialized urinary cytopathology for neoplastic cells. Standardized preparation is important because centrifugation, microscopy, and reporting methods affect results. Automated analyzers can improve consistency, but some findings need manual review.

6.1. Erythrocytes

Urinary erythrocytes indicate possible bleeding after contamination and other causes are considered. Their morphology can help localize the source: dysmorphic cells, including acanthocytes, may support glomerular bleeding, while erythrocyte casts strongly suggest bleeding within the nephron and possible glomerular inflammation. These findings are especially important with proteinuria, hypertension, edema, or impaired renal function. Urine pH, concentration, freshness, and technique affect cell appearance, so microscopy must be interpreted with the clinical picture.

6.2. Leukocytes

Leukocytes commonly accompany urinary inflammation. Increased leukocytes with bacteriuria and compatible symptoms support infection. Leukocyte casts form in renal tubules and can support an intrarenal process such as pyelonephritis, although their absence does not exclude it. Numerous squamous epithelial cells may indicate contamination.

6.3. Epithelial cells

Epithelial cells originate from different urinary-system regions. Numerous squamous cells often suggest external contamination. Transitional cells may come from the renal pelvis, ureters, or bladder and require contextual interpretation. Increased renal tubular epithelial cells may indicate tubular injury from ischemia, toxins, inflammation, or other causes, especially when granular casts or abnormal kidney-function tests are also present. Identification can be difficult and may require repeat testing or expert review.

6.4. Urinary casts

Casts are cylindrical structures formed in renal tubules and collecting ducts from a protein matrix that may contain cells or debris. Hyaline casts can occur after exercise or dehydration without disease. Erythrocyte casts support intrarenal bleeding, usually glomerular inflammation; leukocyte casts suggest renal inflammation, including pyelonephritis or interstitial nephritis; tubular-cell casts suggest tubular injury. Granular casts have varied

significance, while waxy or broad casts may occur in advanced or chronic disease. Interpret casts with other urine findings, kidney function, and symptoms.

6.5. Crystals

Crystals form when dissolved substances precipitate; formation depends on concentration, pH, temperature, and specimen composition. Some occur in healthy children, while others may be associated with stones or metabolic disorders. Crystals can be relevant in recurrent abdominal or flank pain, hematuria, or suspected stone disease, but do not prove a calculus. Imaging and metabolic testing may be needed.

6.6. Bacteria and other microorganisms

Microscopic bacteria do not alone prove infection because contamination is common, especially with poor collection or collection bags. Bacteriuria with leukocyturia, compatible symptoms, and positive culture gives stronger evidence. Culture identifies the organism and may provide antimicrobial susceptibility. Yeast or unusual findings must be interpreted with symptoms, immune status, collection quality, and risk factors; unexpected results may need repeat testing.

7.1. Glomerulonephritis

Glomerulonephritis affects the glomeruli and may cause hematuria, proteinuria, erythrocyte casts, reduced kidney function, edema, and hypertension. Hematuria with proteinuria and erythrocyte casts suggests a nephritic pattern. Blood tests, complement levels, kidney-function assessment, and further investigations may establish the cause and severity.

7.2. Nephrotic syndrome

Nephrotic syndrome involves substantial urinary protein loss, low serum albumin, edema, and often elevated blood lipids. Dipstick testing supports initial detection and monitoring, while quantitative protein measurement better assesses loss. Serial results help follow disease activity and treatment response and should be considered alongside albumin, edema, weight, renal function, and overall condition.

7.3. Urinary tract infection and pyelonephritis

Urinary tract infection can cause fever and illness in children. Infants may show poor feeding, vomiting, irritability, or unexplained fever rather than urinary symptoms. Leukocyte esterase, nitrites, leukocyturia, and bacteriuria support initial assessment, but culture is important to confirm infection and identify the organism. Pyelonephritis may require further evaluation according to age, illness severity, recurrence, and response to treatment. No single sediment finding replaces clinical assessment and culture.

7.4. Tubular and interstitial disorders

Tubular disorders affect reabsorption of water, electrolytes, glucose, bicarbonate, or low-molecular-weight proteins. Findings may include poor urine concentration, glucosuria without hyperglycemia, or inappropriate substance losses. Tubulointerstitial inflammation may cause leukocyturia, modest proteinuria, and sometimes leukocyte casts. Blood chemistry, urine electrolytes, specialized protein tests, and imaging may be required.

7.5. Acute and chronic kidney dysfunction

Urinalysis can help assess acute kidney injury and chronic kidney disease. Proteinuria, hematuria, casts, and concentration abnormalities may suggest the type of damage, but urine testing alone cannot measure overall filtration. Serum creatinine, estimated glomerular

filtration rate, electrolytes, blood pressure, growth, and imaging may be needed. Persistent abnormalities are more concerning than transient findings during fever or dehydration.

8. Integrating Laboratory and Cytological Findings

Physical, chemical, and microscopic findings are most useful when combined. Edema, substantial proteinuria, and low serum albumin suggest nephrotic syndrome; dark urine with proteinuria, dysmorphic erythrocytes, and erythrocyte casts raises concern for glomerular disease. Fever with leukocyturia, positive leukocyte esterase, bacteriuria, and compatible symptoms suggests infection and may require culture. Mild proteinuria during fever can be transient, while many squamous cells and mixed bacteria may indicate contamination. Patterns, repeat tests, and complementary investigations help determine cause and severity.

9. Limitations of Urine Laboratory Examination

Urinalysis has limitations: contamination may mislead; dipstick sensitivity and specificity vary; microscopy requires trained staff; delayed processing changes formed elements; and reference intervals differ by age and method. A normal result does not exclude every renal disorder. Abnormalities should be considered with symptoms, blood pressure, blood tests, imaging, and clinical course. Persistent or combined concerning findings warrant appropriate assessment and possible pediatric nephrology referral.

10. Discussion

The reviewed literature supports routine urinalysis and sediment microscopy in pediatric nephrology. Dipsticks provide rapid preliminary results, microscopy characterizes formed elements, quantitative protein ratios assess persistent proteinuria, and culture helps confirm bacterial infection. Standardized collection, timely processing, age-appropriate reference ranges, clear reporting units, and clinical context improve reliability. Screening results guide further evaluation rather than establish a diagnosis; a negative screen should not stop investigation when symptoms strongly suggest renal disease. Urine tests complement blood tests, including creatinine, electrolytes, and albumin, as well as imaging when indicated. Training healthcare workers in pediatric interpretation may reduce missed diagnoses and unnecessary testing.

11. Conclusion

Urine laboratory testing is fundamental in pediatric nephrology. Physical features, specific gravity, pH, protein, blood, leukocyte esterase, nitrites, glucose, and other chemical parameters provide complementary clues. Sediment microscopy identifies cells, casts, crystals, and microorganisms; their morphology and combination may help distinguish glomerular injury, urinary inflammation, and tubular disorders. Reliable interpretation requires good specimen quality, age-appropriate ranges, prompt processing, and correlation with symptoms and examination. Persistent proteinuria, hematuria, marked leukocyturia, pathological casts, or combinations of abnormalities require clinical evaluation. Used alongside blood tests, culture, and imaging when indicated, urinalysis supports early detection, differential diagnosis, and monitoring.

References:

1. Ibragimov M.B., Akbarova R.M. Bolalarda siydik yo'llari a'zolarining anatomo-fiziologik xususiyatlari va kasalliklari [Anatomical and Physiological Characteristics and Diseases of the

- Urinary Organs in Children]. Educational publication. Andijan State Medical Institute library, 2022.
2. Turayeva N.O. Bolalar nefrologiyasi [Pediatric Nephrology]. Educational manual. Samarqand: ARTEX NASHR, 2024. ISBN: 978- 9910- 9039- 3- 9.
 3. Ganfulina L.M., G'oyibova N.S. Bolalar nefrologiyasi asoslari. I tom [Fundamentals of Pediatric Nephrology, Volume I]. Educational manual. Samarqand, 2026. ISBN: 978-9910-252-61-7.
 4. Shabalov N.P. Gospital pediatriya [Hospital Pediatrics]. Uzbek-language educational edition. Available through Tashkent Pediatric Medical Institute educational resources.
 5. Viteri B., Reid-Adam J. Urinary tract infection in children. Pediatrics in Review. 2018;39(1):3–12. doi:10.1542/pir.2017- 0007.
 6. Hitzeman N., Greer D., Carpio E. Office-based urinalysis: a comprehensive review. American Family Physician. 2022;106(1):27–35.
 7. Urinalysis in Children and Adolescents. Deutsches Ärzteblatt International. 2014. Available at: <https://pmc.ncbi.nlm.nih.gov/articles/PMC4187024/>
 8. Kallash M., Rheault M.N. Approach to persistent microscopic hematuria in children. Kidney360. 2020;1(9):1014–1020.
 9. Bolalarda siydik yo'llari infeksiyalarini tashxislash va davolashga oid zamonaviy klinik tavsiyalar hamda pediatrik urologiya bo'yicha xalqaro qo'llanmalar.
 10. Samsel K., Koper-Lenkiewicz O.M., Matowicka-Karna J., Kamińska J. Pediatric urinalysis revisited: developmental physiology, preanalytical challenges, clinical decision limits, and age- and sex-specific reference intervals. Critical Reviews in Clinical Laboratory Sciences. Published online September 23, 2026. doi:10.1080/10408363.2026.2730967.