THE IMPORTANCE OF LABORATORY INDICATORS IN THE EARLY DETECTION OF CHRONIC KIDNEY DISEASE

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Abstract Chronic kidney disease (CKD) is a progressive and irreversible condition associated with significant morbidity, mortality, and healthcare burden worldwide. Early detection is crucial for slowing disease progression, preventing complications, and improving patient outcomes. Laboratory biomarkers play a central role in identifying kidney damage before the onset of clinical symptoms. This article reviews the diagnostic value of key laboratory indicators—including serum creatinine, estimated glomerular filtration rate (eGFR), albuminuria, cystatin C, and emerging biomarkers—in the early detection of CKD. Emphasis is placed on their clinical utility, limitations, and role in screening high-risk populations. Early laboratory-based diagnosis remains essential for timely intervention and effective disease management.

Keywords: chronic kidney disease, early diagnosis, laboratory biomarkers, eGFR, albuminuria, cystatin C

Introduction

Chronic kidney disease represents a major global public health challenge, affecting approximately 10–15% of the adult population. [1,2,3,4] The disease is characterized by a gradual decline in renal function lasting longer than three months and may progress to end-stage renal disease (ESRD), requiring dialysis or kidney transplantation. [5,6,7,8] Because early CKD is often asymptomatic, laboratory testing is fundamental for timely detection. Identification of reliable and sensitive laboratory markers enables clinicians to initiate preventive strategies and reduce complications such as cardiovascular disease, anemia, and mineral-bone disorders.[9,10,11,12]

Pathophysiological Basis of CKD Progression

CKD results from structural or functional kidney abnormalities caused by diabetes mellitus, hypertension, glomerulonephritis, genetic disorders, or toxic exposures.[13,14,15,16] Progressive nephron loss leads to compensatory hyperfiltration in remaining nephrons, eventually causing fibrosis, inflammation, and irreversible decline in glomerular filtration rate. Laboratory abnormalities often appear before clinical manifestations, making biochemical testing the cornerstone of early diagnosis.[17,18,19,20]

Key Laboratory Indicators for Early CKD Detection

1. Serum Creatinine and Estimated Glomerular Filtration Rate (eGFR)

Serum creatinine is the most widely used marker of kidney function. However, creatinine alone is insufficient because it is influenced by age, sex, muscle mass, and diet.

Therefore, equations such as CKD-EPI are used to calculate eGFR, providing a more accurate assessment of renal filtration capacity.[21,22,23,24]

Clinical significance: eGFR <60 mL/min/1.73 m² for ≥3 months indicates CKD.

Limitations: Reduced sensitivity in early disease and variability among populations.[25,26]

2. Albuminuria and Urine Albumin-to-Creatinine Ratio (UACR)

Albuminuria is one of the earliest markers of kidney damage, especially in diabetic and hypertensive patients. Measurement of UACR in a spot urine sample is recommended for screening.[27,28,29]

Microalbuminuria: 30–300 mg/g

Macroalbuminuria:>300mg/g

Persistent albuminuria strongly predicts CKD progression and cardiovascular risk.[30,31,32]

3. Cystatin C

Cystatin C is a low-molecular-weight protein produced by all nucleated cells and freely filtered by glomeruli. Unlike creatinine, it is minimally affected by muscle mass or diet.[33,34,35]

Clinical value: Detects mild reductions in kidney function and improves risk stratification when combined with creatinine-based eGFR.

Limitations: Higher cost and limited availability in some regions.

4. Blood Urea Nitrogen (BUN)

BUN reflects nitrogen metabolism and renal excretory function. Although nonspecific and influenced by hydration and protein intake, elevated BUN may support CKD diagnosis when interpreted alongside other markers.[36,37,38]

5. Emerging Biomarkers

Recent studies highlight novel indicators such as:

Neutrophil gelatinase-associated lipocalin (NGAL)

Kidney injury molecule-1 (KIM-1)

Beta-trace protein and beta-2 microglobulin

These biomarkers may detect tubular injury earlier than traditional tests, offering promise for future screening strategies.

Role of Laboratory Screening in High-Risk Populations

Routine laboratory screening is strongly recommended for individuals with:

Diabetes mellitus

Hypertension

Cardiovascular disease

Family history of kidney disease

Advanced age or obesity

Annual assessment of eGFR and UACR enables early intervention, including blood pressure control, glycemic management, and renoprotective pharmacotherapy.[41]

Clinical Implications and Preventive Strategies

Early laboratory detection allows implementation of evidence-based interventions:

Renin-angiotensin-aldosterone system (RAAS) blockade

Sodium–glucose cotransporter-2 (SGLT2) inhibitors

Lifestyle modification and dietary management

Monitoring of anemia and mineral-bone metabolism

Such measures significantly delay CKD progression and reduce cardiovascular complications.[39,40]

Conclusion

Laboratory indicators are indispensable for the early detection and monitoring of chronic kidney disease. While serum creatinine-based eGFR and albuminuria remain the primary diagnostic tools, cystatin C and emerging biomarkers provide improved sensitivity for early renal impairment. Systematic laboratory screening of high-risk populations enables timely therapeutic intervention and reduces the global burden of CKD. Future research should focus on integrating novel biomarkers into routine clinical practice to enhance early diagnosis and personalized treatment.

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