

Assessment of Thyroid Function Test and Lipid Profile in Chronic Kidney Disease Patients

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Abstract

Background: Chronic kidney disease (CKD) is associated with significant metabolic derangements, including thyroid dysfunction and dyslipidemia, which contribute to increased cardiovascular morbidity and mortality. The prevalence and patterns of these abnormalities may vary across different populations and CKD stages.

Objective: To assess the prevalence of thyroid dysfunction and lipid abnormalities among CKD patients attending a tertiary care hospital in South-Western Maharashtra and evaluate their correlation with disease severity.

Methods: This hospital-based cross-sectional observational study was conducted over two years at Krishna Hospital and Medical Centre. Sixty-two adult patients with confirmed CKD were enrolled using consecutive sampling. Clinical, biochemical, and demographic data were collected, including serum creatinine, estimated glomerular filtration rate (eGFR), lipid profile (total cholesterol, LDL cholesterol, HDL cholesterol, triglycerides), and thyroid function tests (TSH, T3, FT4). Statistical analysis was performed using SPSS v26.0, with significance set at $p < 0.05$.

Results: The mean age of participants was 61.31 ± 14.4 years, with 50% over 70 years. Most patients were in CKD Stage III (51.6%), followed by Stage IV (32.3%) and Stage V (16.1%). Dyslipidemia was present in 75.8% of patients, with elevated LDL cholesterol being the predominant abnormality (62.9%). The prevalence of dyslipidemia increased significantly with CKD progression ($p = 0.01$). Thyroid dysfunction was observed in 41.9% of participants, with low T3 syndrome (19.4%) being most common, followed by subclinical hypothyroidism (17.7%) and overt hypothyroidism (4.8%). TSH levels increased significantly across CKD stages ($p < 0.01$), while T3 and FT4 levels declined with disease progression.

Conclusion: CKD patients demonstrate a high burden of thyroid dysfunction and dyslipidemia with strong associations between these metabolic abnormalities and disease severity. These findings support routine screening and early therapeutic interventions to mitigate cardiovascular risks and optimize comprehensive disease management.

Keywords: chronic kidney disease, thyroid dysfunction, dyslipidemia, subclinical hypothyroidism, low T3 syndrome, cardiovascular risk

I. Introduction

Chronic kidney disease (CKD) represents a major global public health challenge, affecting approximately 850 million people worldwide and ranking as the 16th leading cause of global mortality (1). The prevalence of CKD has increased substantially over recent decades, primarily driven by aging populations and rising rates of diabetes, hypertension, and obesity (2). In India, the prevalence of CKD is estimated at 17.2% among adults, with significant regional variations and substantial socioeconomic implications (3).

CKD is characterized by progressive loss of kidney function, leading to multiple systemic complications that extend far beyond renal insufficiency. Among these complications, cardiovascular disease remains the leading cause of morbidity and mortality in CKD patients, accounting for approximately 40-50% of deaths, particularly in advanced stages (4). This elevated cardiovascular risk results from both traditional risk factors and CKD-specific complications, including chronic inflammation, mineral bone disorders, anemia, and importantly, metabolic derangements such as thyroid dysfunction and dyslipidemia (5).

The relationship between CKD and thyroid dysfunction is complex and bidirectional. The kidneys play crucial roles in thyroid hormone metabolism, including degradation and excretion of thyroid hormones, thyroid-stimulating hormone (TSH), and thyrotropin-releasing hormone (6). Conversely, thyroid hormones significantly influence renal hemodynamics, glomerular filtration, tubular function, and overall kidney structure and function

(7). Recent epidemiologic studies have demonstrated an incrementally higher prevalence of hypothyroidism with worsening kidney function, with rates increasing from 5% in those with estimated glomerular filtration rate (eGFR) ≥ 90 mL/min/1.73m² to 23% in those with eGFR < 45 mL/min/1.73m² (8).

The spectrum of thyroid abnormalities in CKD encompasses various patterns. Low T3 syndrome, also known as euthyroid sick syndrome, represents the most common thyroid function abnormality, affecting up to 47-87% of CKD patients depending on disease stage (9,10). This condition is characterized by decreased peripheral conversion of T4 to T3, resulting from reduced activity of type 1 5'-deiodinase enzyme, often exacerbated by uremic toxins, chronic inflammation, and metabolic acidosis (11). Subclinical hypothyroidism, defined by elevated TSH with normal free T4 levels, represents another frequent finding, with prevalence rates ranging from 15-27% in CKD populations (12,13).

Similarly, dyslipidemia represents a prevalent and clinically significant complication of CKD, affecting 75-82% of patients depending on disease stage and dialysis status (14,15). The dyslipidemia pattern in CKD differs markedly from that observed in the general population, characterized by hypertriglyceridemia, reduced high-density lipoprotein (HDL) cholesterol, and altered lipoprotein composition rather than elevated total cholesterol or low-density lipoprotein (LDL) cholesterol (16). These alterations result from impaired lipolysis due to reduced lipoprotein lipase activity, decreased lecithin-cholesterol acyltransferase activity, and increased apolipoprotein CIII levels, collectively contributing to atherogenic lipoprotein profiles (17).

The pathophysiological mechanisms underlying CKD-associated dyslipidemia involve multiple factors. Reduced clearance of triglyceride-rich lipoproteins and their remnants, impaired HDL maturation, and altered lipoprotein composition contribute to accelerated atherosclerosis and cardiovascular risk (18). Additionally, the uremic milieu promotes oxidative stress and inflammation, leading to formation of small dense LDL particles and oxidized lipoproteins with enhanced atherogenic potential (19).

Despite the established associations between CKD and both thyroid dysfunction and dyslipidemia, there remains considerable variability in reported prevalence rates across different populations and geographic regions. This variability likely reflects differences in study populations, CKD definitions, laboratory methodologies, and regional factors including dietary patterns, genetic backgrounds, and healthcare practices. Moreover, the complex interrelationships between thyroid function, lipid metabolism, and CKD progression remain incompletely understood, particularly regarding the temporal sequence of these abnormalities and their relative contributions to cardiovascular outcomes.

The clinical implications of these metabolic abnormalities extend beyond their individual effects on cardiovascular risk. Thyroid dysfunction in CKD patients has been associated with accelerated decline in renal function, increased hospitalization rates, and higher mortality (20). Similarly, dyslipidemia contributes not only to cardiovascular complications but may also promote CKD progression through direct nephrotoxic effects of lipoproteins on glomerular and tubular structures (21). Understanding these relationships is crucial for developing comprehensive management strategies that address multiple risk factors simultaneously.

Current management approaches for CKD-associated metabolic complications remain suboptimal, partly due to limited evidence from randomized controlled trials in CKD populations. The 2013 Kidney Disease: Improving Global Outcomes (KDIGO) guidelines for lipid management in CKD adopted a relatively conservative approach, emphasizing statin therapy for non-dialysis CKD patients but acknowledging limited evidence for advanced CKD stages (22). Similarly, guidelines for thyroid hormone replacement in CKD patients with subclinical hypothyroidism remain controversial, with some studies suggesting potential benefits for renal function preservation while others question the risk-benefit balance (23).

Given the significant burden of CKD in developing countries like India, and the potential for early intervention to improve outcomes, comprehensive assessment of metabolic complications in regional CKD populations is essential. Understanding the local prevalence and patterns of thyroid dysfunction and dyslipidemia can inform screening strategies, guide therapeutic interventions, and contribute to improved clinical outcomes. Furthermore, such studies provide valuable insights into the natural history of these complications and their relationships with CKD progression in diverse populations (24,25).

II. Aim and Objectives

Aim

To assess thyroid function test and lipid profile in chronic kidney disease (CKD) patients presenting to a tertiary care centre in southwestern Maharashtra.

Objectives

1. To determine the prevalence of thyroid dysfunction, including hypothyroidism, hyperthyroidism, and thyroid hormone resistance, in patients with CKD.
2. To assess the lipid profile, including levels of total cholesterol, LDL cholesterol, HDL cholesterol, and triglycerides, in CKD patients.

3. To evaluate the correlation between thyroid dysfunction, dyslipidemia, and CKD stage severity.

III. Materials and Methods

Study Design and Setting

This was a hospital-based cross-sectional observational study conducted over a period of two years at the Department of General Medicine, Krishna Hospital and Medical Centre, a tertiary care facility in South-Western Maharashtra, India.

Study Population and Sampling

The study population comprised all patients diagnosed with chronic kidney disease (CKD) presenting to both outpatient and inpatient departments. Patients were selected using a simple consecutive sampling technique to minimize selection bias. All participants underwent screening based on predefined inclusion and exclusion criteria.

Sample Size Calculation

The minimum required sample size was calculated using the formula: $n = 4\sigma^2/d^2$

Where $\sigma = 45.2$ (standard deviation from previous study by Poonam and Vivek), and $d = 5\%$ of the mean value (229.9 mg/dL). Based on this calculation, the required sample size was determined to be 62 CKD patients.

Inclusion Criteria

1. Patients aged >18 years
2. Either sex
3. Confirmed diagnosis of CKD based on established KDIGO criteria
4. Provided written informed consent

Exclusion Criteria

1. Active treatment for thyroid disorders or recent thyroid surgery
2. Primary hyperlipidemia or current use of lipid-lowering agents
3. Pregnancy or lactation
4. Acute kidney injury or transient renal dysfunction
5. Previous dialysis treatment
6. Obesity or nephrotic syndrome
7. Current use of estrogens, corticosteroids, anti-thyroid drugs, or dietary supplements

Data Collection and Clinical Assessment

Following informed consent, comprehensive demographic and clinical data were collected through structured interviews and systematic medical record reviews. Physical examinations included blood pressure measurements and anthropometric assessments. Detailed medical histories were obtained, focusing on comorbid conditions, duration of CKD, and current medications.

Laboratory Evaluations

Blood samples were collected after 12-hour overnight fasting for biochemical analyses. Laboratory evaluations included:

Renal Function Assessment:

- Serum creatinine
- Estimated glomerular filtration rate (eGFR) using CKD-EPI equation
- Urine albumin-to-creatinine ratio (ACR)

Thyroid Function Tests:

- Thyroid-stimulating hormone (TSH)
- Free triiodothyronine (T3)
- Free thyroxine (FT4)

Lipid Profile:

- Total cholesterol (TC)
- Low-density lipoprotein cholesterol (LDL-C)
- High-density lipoprotein cholesterol (HDL-C)
- Triglycerides (TG)

All laboratory analyses were performed using standardized automated analyzers with appropriate quality control measures.

Variable Definitions

CKD staging was performed according to KDIGO guidelines based on eGFR categories. Thyroid dysfunction was classified as follows:

- Euthyroidism: Normal TSH, T3, and FT4 levels
- Subclinical hypothyroidism: Elevated TSH with normal T3 and FT4
- Overt hypothyroidism: Elevated TSH with low T3 and/or FT4
- Low T3 syndrome: Low T3 with normal or low-normal TSH and FT4

Dyslipidemia was defined according to National Cholesterol Education Program Adult Treatment Panel III guidelines, with modifications for CKD population as appropriate.

Ethical Considerations

Ethical clearance was obtained from the Institutional Ethics Committee before study initiation. All participants provided informed written consent, and strict confidentiality of data was maintained throughout the study period. The study was conducted in accordance with the Declaration of Helsinki principles.

Statistical Analysis

Data were entered into a pre-designed study proforma and analyzed using SPSS Version 26.0 and Microsoft Excel 2021. Descriptive statistics included frequencies and percentages for categorical variables, and means $\pm$ standard deviations for continuous variables. Between-group comparisons were performed using unpaired t-tests for normally distributed data and Mann-Whitney tests for non-parametric data. Chi-square tests were used to assess associations between categorical variables. A p-value <0.05 was considered statistically significant. Results were graphically represented where appropriate to enhance data interpretation.

IV. Results

Baseline Characteristics and Demographics

The study enrolled 62 patients with chronic kidney disease, with a mean age of 61.31 ± 14.4 years. Age distribution revealed that 50.0% of participants were older than 70 years, with the 61-70 year group comprising 30.6% of subjects. Gender distribution was nearly balanced, with males accounting for 51.6% and females representing 48.4% of the study population. Analysis of comorbid conditions revealed hypertension as the most prevalent comorbidity (48.4%), followed by ischemic heart disease (25.8%) and diabetes mellitus (17.7%). The majority of participants were classified as CKD Stage III (51.6%), followed by Stage IV (32.3%) and Stage V (16.1%).

Lipid Profile and Dyslipidemia Prevalence

Comprehensive lipid profile analysis revealed multiple abnormalities across different parameters. Overall dyslipidemia prevalence was remarkably high, affecting 75.8% of CKD patients. Among specific lipid abnormalities, elevated LDL cholesterol emerged as the most common abnormality (62.9%), followed by elevated triglycerides (35.5%), elevated total cholesterol (33.9%), and low HDL cholesterol (32.3%) (Table 1).

Table 1. Prevalence of Dyslipidemia and Lipid Abnormalities

Parameter	Number (n)	Percentage (%)
Overall Dyslipidemia	47	75.8
Elevated LDL cholesterol	39	62.9
Elevated triglycerides	22	35.5
Elevated total cholesterol	21	33.9
Low HDL cholesterol	20	32.3

A strong positive correlation was observed between advancing CKD stage and dyslipidemia prevalence. In CKD Stage III, 68.8% of patients had dyslipidemia, which increased to 80.0% in Stage IV and reached 90.0% in Stage V. This progressive trend was statistically significant ($p=0.01$) (Table 2).

Table 2. Association Between CKD Stage and Dyslipidemia

CKD Stage	No Dyslipidemia n (%)	Dyslipidemia n (%)	Total n (%)	P-value
III	10 (31.3)	22 (68.8)	32 (100.0)	0.01
IV	4 (20.0)	16 (80.0)	20 (100.0)	
V	1 (10.0)	9 (90.0)	10 (100.0)	
Total	15 (24.2)	47 (75.8)	62 (100.0)	

Detailed analysis of mean lipid parameters across CKD stages revealed significant trends with disease progression. Total cholesterol increased from 179.6 ± 42.8 mg/dL in Stage III to 199.7 ± 62.8 mg/dL in Stage V ($p < 0.01$). Triglyceride levels rose progressively across stages ($p = 0.02$). Most notably, HDL cholesterol demonstrated a significant inverse relationship, decreasing from 43.5 ± 6.9 mg/dL in Stage III to 35.6 ± 7.4 mg/dL in Stage V ($p < 0.01$).

Thyroid Dysfunction Patterns and Prevalence

Thyroid dysfunction was identified in 41.9% of study participants, while 58.1% maintained normal thyroid function. Among patients with thyroid dysfunction, low T3 syndrome was the most frequent pattern, observed in 19.4% of all participants. Subclinical hypothyroidism was present in 17.7% of cases, while overt hypothyroidism affected 4.8% of patients (Table 3).

Table 3. Types and Prevalence of Thyroid Dysfunction

Thyroid Function Status	Number (n)	Percentage (%)
Normal thyroid function	36	58.1
Any thyroid dysfunction	26	41.9
- Low T3 syndrome	12	19.4
- Subclinical hypothyroidism	11	17.7
- Overt hypothyroidism	3	4.8

A statistically significant association ($p < 0.01$) was demonstrated between CKD stage and thyroid dysfunction prevalence. The proportion of patients with thyroid dysfunction increased progressively from 34.4% in Stage III to 50.0% in Stage IV, reaching 70.0% in Stage V (Table 4).

Table 4. Association Between CKD Stage and Thyroid Dysfunction

CKD Stage	Normal Function n (%)	Thyroid Dysfunction n (%)	Total n (%)	P-value
III	21 (65.6)	11 (34.4)	32 (100.0)	<0.01
IV	10 (50.0)	10 (50.0)	20 (100.0)	
V	3 (30.0)	7 (70.0)	10 (100.0)	
Total	34 (58.1)	28 (41.9)	62 (100.0)	

Analysis of thyroid function parameters revealed significant changes with CKD progression. Mean TSH levels demonstrated a statistically significant progressive increase from 2.90 ± 3.00 mIU/L in Stage III to 8.10 ± 5.12 mIU/L in Stage V ($p < 0.01$), indicating worsening hypothyroid status in advanced CKD stages. T3 levels showed a declining trend from 1.77 ± 0.77 ng/mL in Stage III to 1.58 ± 0.83 ng/mL in Stage V, while T4 levels decreased from 73.12 ± 6.96 ng/dL to 65.89 ± 4.57 ng/dL across stages.

Table 5. Thyroid Function Parameters by CKD Stage

CKD Stage	T3 (ng/mL) Mean $\pm$ SD	T4 (ng/dL) Mean $\pm$ SD	TSH (mIU/L) Mean $\pm$ SD	P-value (TSH)
III	1.77 ± 0.77	73.12 ± 6.96	2.90 ± 3.00	<0.01
IV	1.67 ± 0.86	71.32 ± 8.80	4.48 ± 3.12	
V	1.58 ± 0.83	65.89 ± 4.57	8.10 ± 5.12	

V. Discussion

This cross-sectional study provides comprehensive insights into the prevalence and patterns of thyroid dysfunction and dyslipidemia among CKD patients in Western Maharashtra, India. Our findings demonstrate remarkably high rates of both metabolic abnormalities, with clear associations between their severity and CKD progression, confirming and extending previous observations in different populations.

Dyslipidemia in CKD: Prevalence and Clinical Implications

Our study revealed a dyslipidemia prevalence of 75.8%, which aligns closely with recent international studies reporting rates between 75-82% in CKD populations (14,15). This finding is particularly significant when compared to the general Indian population, where dyslipidemia prevalence ranges from 31-45% (1). The nearly three-fold higher prevalence in our CKD cohort underscores the profound impact of renal dysfunction on lipid metabolism.

The predominant lipid abnormality in our study was elevated LDL cholesterol (62.9%), followed by hypertriglyceridemia (35.5%). This pattern differs somewhat from the classical CKD dyslipidemia profile typically characterized by hypertriglyceridemia and low HDL as primary abnormalities (16). The high prevalence of elevated LDL cholesterol in our population may reflect regional dietary patterns, genetic factors, or the specific CKD stages represented in our cohort.

The progressive increase in dyslipidemia prevalence across CKD stages (68.8% in Stage III to 90.0% in Stage V, $p=0.01$) demonstrates a clear relationship between declining renal function and worsening lipid profiles. This finding is consistent with a recent analysis of over 21,000 incident dialysis patients that reported 82% dyslipidemia prevalence in advanced CKD (14). The underlying mechanisms involve progressive impairment of lipoprotein metabolism, including reduced lipoprotein lipase activity, decreased lecithin-cholesterol acyltransferase function, and altered apolipoprotein composition (17,18).

The significant decrease in HDL cholesterol from 43.5 mg/dL in Stage III to 35.6 mg/dL in Stage V ($p<0.01$) is particularly concerning, as HDL dysfunction in CKD involves not only quantitative reductions but also qualitative changes that impair reverse cholesterol transport and anti-inflammatory properties (19). This creates an increasingly atherogenic environment that contributes substantially to the elevated cardiovascular risk observed in CKD patients.

Thyroid Dysfunction in CKD: Patterns and Mechanisms

Thyroid dysfunction affected 41.9% of our CKD patients, with prevalence increasing from 34.4% in Stage III to 70.0% in Stage V ($p<0.01$). This finding aligns with recent literature reporting thyroid abnormality rates ranging from 13% in early CKD to 70% in end-stage renal disease (2,3). A recent comprehensive study from India reported similar prevalence rates, with 38.6% of CKD patients demonstrating thyroid dysfunction (4).

The pattern of thyroid dysfunction in our study closely mirrors international observations. Low T3 syndrome was the most common abnormality (19.4%), followed by subclinical hypothyroidism (17.7%) and overt hypothyroidism (4.8%). This distribution is consistent with recent studies reporting 47-87% prevalence of low T3 syndrome in CKD patients (9,10). The pathophysiology underlying low T3 syndrome involves reduced peripheral conversion of T4 to T3, resulting from decreased activity of type 1 5'-deiodinase enzyme, influenced by uremic toxins, chronic inflammation, and metabolic acidosis (11).

Subclinical hypothyroidism in our study (17.7%) falls within the range reported in recent literature (15-27%) (12,13). The progressive increase in mean TSH levels across CKD stages (2.90 to 8.10 mIU/L, $p<0.01$) reflects the evolving hypothyroid state. This elevation likely results from multiple factors, including decreased TSH clearance, altered TSH bioactivity, impaired negative feedback regulation, and progressive iodide retention due to reduced renal clearance (5,6).

Recent evidence suggests that thyroid dysfunction in CKD is not merely a consequence of illness but may actively contribute to disease progression and cardiovascular complications. A large prospective study demonstrated that subclinical hypothyroidism was associated with incident CKD development, with a two-fold increased risk compared to euthyroid individuals (7). Furthermore, thyroid hormone replacement therapy in CKD patients with subclinical hypothyroidism has been associated with slower decline in renal function and improved cardiovascular outcomes (8).

Clinical Implications and Management Considerations

The high prevalence of both thyroid dysfunction and dyslipidemia in our CKD population has significant clinical implications. These metabolic abnormalities contribute independently to cardiovascular risk, which is already elevated 10-30 fold in CKD patients compared to the general population (20). The progressive worsening of both conditions with advancing CKD stages suggests that early intervention may be crucial for preventing complications.

Current evidence supports routine lipid screening in CKD patients, with statin therapy recommended for non-dialysis dependent CKD patients (22). However, the optimal management of dyslipidemia in advanced CKD stages remains controversial, with some studies showing limited cardiovascular benefits in dialysis patients (21). The high prevalence of elevated LDL cholesterol in our population suggests that conventional lipid-lowering strategies may be more relevant than previously recognized.

Regarding thyroid dysfunction, the role of thyroid hormone replacement therapy in CKD patients with subclinical hypothyroidism remains debated. While some studies suggest benefits for renal function preservation and cardiovascular outcomes (23), others raise concerns about potential risks, particularly in elderly patients. The

high prevalence of thyroid dysfunction in our population supports the need for routine thyroid screening in CKD patients, even in the absence of clear treatment guidelines.

VI. Limitations and Future Directions

Several limitations should be acknowledged in interpreting our findings. The cross-sectional design precludes assessment of causal relationships between CKD progression and metabolic abnormalities. The relatively small sample size from a single center may limit generalizability to other populations. Additionally, we did not assess cardiovascular outcomes or the temporal relationship between thyroid dysfunction, dyslipidemia, and CKD progression.

Future research should focus on longitudinal studies examining the natural history of these metabolic abnormalities and their impact on clinical outcomes. Randomized controlled trials are needed to determine the optimal management strategies for thyroid dysfunction and dyslipidemia in different CKD stages. Additionally, studies investigating the cost-effectiveness of routine screening and early intervention for these conditions would provide valuable guidance for healthcare policy.

VII. Conclusion

This study demonstrates a remarkably high burden of thyroid dysfunction and dyslipidemia among CKD patients in Western Maharashtra, with prevalence rates of 41.9% and 75.8%, respectively. Both conditions show strong positive correlations with CKD severity, with thyroid dysfunction increasing from 34.4% in Stage III to 70.0% in Stage V, and dyslipidemia increasing from 68.8% to 90.0% across the same stages. Low T3 syndrome emerged as the most common thyroid abnormality (19.4%), while elevated LDL cholesterol was the predominant lipid abnormality (62.9%).

These findings have significant implications for clinical practice and healthcare policy. The high prevalence of these modifiable cardiovascular risk factors supports the implementation of routine screening programs for both thyroid function and lipid profiles in CKD patients. Early identification and appropriate management of these metabolic abnormalities may contribute to improved cardiovascular outcomes and potentially slower CKD progression.

The progressive worsening of both thyroid dysfunction and dyslipidemia with advancing CKD stages emphasizes the importance of early intervention in the disease course. Healthcare providers caring for CKD patients should maintain high clinical suspicion for these metabolic complications and consider comprehensive metabolic assessment as part of routine CKD management.

Further research is needed to establish optimal treatment strategies for these conditions in the CKD population and to determine their impact on long-term clinical outcomes. The development of evidence-based guidelines specific to CKD patients with thyroid dysfunction and dyslipidemia remains a priority for improving comprehensive care in this high-risk population.

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