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RESEARCH ARTICLE
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TYPE 2 DIABETES MELLITUS PATIENTS WITH CHRONIC KIDNEY DISEASE: RELATIONSHIP WITH THYROID DYSFUNCTION, OXIDATIVE STRESS, C-REACTIVE PROTEIN AND IL-6 IN PATIENTS ATTENDING A TERTIARY CARE HOSPITAL

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ABSTRACT

Background

Type 2 diabetes mellitus (T2DM) is a major metabolic disorder associated with progressive renal impairment. Chronic kidney disease (CKD) in diabetic patients may be accompanied by thyroid dysfunction, increased oxidative stress, and chronic low-grade inflammation. Thyroid-stimulating hormone (TSH), free thyroid hormones, malondialdehyde (MDA), superoxide dismutase (SOD), C-reactive protein (CRP), and interleukin-6 (IL-6) may therefore provide useful information regarding the interaction between metabolic, renal, oxidative, and inflammatory abnormalities.

Aim

To assess the relationship of thyroid dysfunction, oxidative stress, CRP, and IL-6 with CKD among patients with T2DM attending a tertiary care hospital.

Materials and Methods

A cross-sectional study was designed involving 100 patients with T2DM. Based on renal parameters, including estimated glomerular filtration rate (eGFR) and urinary albumin-to-creatinine ratio, participants were categorized into 35 CKD-positive and 65 CKD-negative patients. Demographic and clinical characteristics were recorded. Blood samples were assessed for fasting blood glucose, HbA1c, serum urea, creatinine, TSH, free T3, free T4, MDA, SOD, glutathione, CRP, and IL-6. Urinary ACR and eGFR were also evaluated. Statistical comparisons and correlation analysis were performed.

Results

CKD-positive patients had significantly higher serum urea, creatinine, urinary ACR, and HbA1c and significantly lower eGFR than CKD-negative patients. Thyroid abnormalities were more frequent among CKD-positive patients, with higher TSH and lower free T3 and free T4 levels. Thyroid dysfunction was observed in 12 (34.3%) CKD-positive patients compared with 8 (12.3%)

CKD-negative patients. MDA was significantly increased, whereas SOD and glutathione were reduced in the CKD group. Inflammatory markers were also significantly elevated, with higher CRP and IL-6 concentrations among CKD-positive patients. eGFR showed negative correlations with TSH, MDA, CRP, and IL-6 and positive correlations with free T3 and SOD.

Conclusion

Among patients with T2DM, CKD was associated with thyroid dysfunction, increased oxidative stress, impaired antioxidant defense, and enhanced systemic inflammation. The observed associations between eGFR and TSH, MDA, CRP, and IL-6 suggest that declining renal function may occur alongside abnormalities in thyroid, oxidative, and inflammatory pathways. Further prospective studies involving larger populations are required to establish the temporal and causal relationships between these parameters.

Key words: Type 2 diabetes mellitus; chronic kidney disease; thyroid dysfunction; TSH; oxidative stress; MDA; CRP; IL-6; eGFR; inflammation.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycaemia resulting from insulin resistance, progressive β-cell dysfunction, or a combination of both. The worldwide burden of T2DM continues to increase, with substantial consequences for cardiovascular, renal, neurological, and other organ systems. Chronic kidney disease (CKD) is one of the most important long-term complications of diabetes and represents a major cause of morbidity and mortality among individuals with T2DM. Recent global analyses demonstrate a substantial and increasing burden of CKD attributable to T2DM, particularly in ageing populations and regions undergoing rapid epidemiological transition. [1–3]

Diabetic kidney disease is characterized by progressive renal structural and functional abnormalities, which may manifest as albuminuria, declining estimated glomerular filtration rate (eGFR), or both. The development and progression of diabetic kidney disease are influenced by the duration of diabetes, glycaemic control, hypertension, obesity, ageing, and other metabolic and vascular factors. A systematic review and meta-analysis reported a pooled CKD prevalence of approximately 27% among patients with T2DM, although considerable geographical variation exists. [4]

The pathogenesis of diabetic kidney disease is complex and involves multiple interrelated mechanisms, including hyperglycaemia, advanced glycation end products, activation of protein kinase pathways, haemodynamic alterations, oxidative stress, inflammation, endothelial dysfunction, and fibrosis. Persistent hyperglycaemia promotes excessive production of reactive oxygen species (ROS), which can damage lipids, proteins, DNA, and cellular organelles. Oxidative stress also interacts with inflammatory pathways, creating a potentially self-perpetuating cycle that contributes to glomerular and tubular injury. [5,6]

Oxidative stress is therefore considered an important component of diabetic kidney disease. Increased ROS generation can arise from mitochondrial dysfunction, NADPH oxidase activity, and other intracellular pathways, while endogenous antioxidant mechanisms may become insufficient to neutralize the excess reactive species. Malondialdehyde (MDA), a product of lipid peroxidation, is frequently investigated as a marker of oxidative damage, whereas enzymes such as superoxide dismutase (SOD) and reduced glutathione contribute to the antioxidant defense system. An imbalance between oxidant generation and antioxidant capacity may promote cellular injury and accelerate renal dysfunction. [7,8]

Inflammation represents another important mechanism in the progression of diabetic kidney disease. Chronic metabolic abnormalities associated with diabetes can activate inflammatory signaling pathways within the kidney, resulting in production of cytokines and chemokines, recruitment of inflammatory cells, endothelial dysfunction, and extracellular matrix accumulation. Oxidative stress and inflammation are closely interconnected, with ROS capable of activating inflammatory signaling while inflammatory processes can further increase oxidative injury. [6,9]

C-reactive protein (CRP) is a widely used systemic marker of inflammation. Increased

inflammatory activity has been associated with renal dysfunction and adverse outcomes in patients with diabetes and CKD. Interleukin-6 (IL-6), a multifunctional pro-inflammatory cytokine, is also involved in the inflammatory response associated with diabetic kidney disease. Experimental and clinical evidence indicates that IL-6-related signaling may contribute to immune activation, metabolic abnormalities, renal cellular injury, and progression of diabetic kidney disease. [9,10]

Thyroid function is another potentially important factor in patients with CKD. Thyroid hormones have physiological effects on renal development, renal blood flow, glomerular filtration, electrolyte and water balance, and vascular function. Consequently, alterations in thyroid function can influence renal physiology, while impaired kidney function can itself alter thyroid hormone metabolism and distribution. This bidirectional relationship makes thyroid dysfunction particularly relevant in patients with chronic renal disease. [11]

Several studies have reported an association between CKD and altered thyroid hormone profiles, particularly increased serum thyroid-stimulating hormone (TSH) and reduced free triiodothyronine (free T3). A recent review suggested that higher TSH and lower free T3 are relatively consistent findings in relation to reduced renal function, although the relationship between free thyroxine (free T4) and CKD remains less consistent. [12]

The relationship between thyroid dysfunction and CKD may involve several mechanisms, including altered thyroid hormone metabolism, reduced peripheral conversion of T4 to T3, changes in iodine metabolism, chronic inflammation, endothelial dysfunction, and effects of thyroid hormones on renal haemodynamics. Conversely, declining renal function may influence circulating thyroid hormone concentrations and their protein binding. Thus, thyroid abnormalities in CKD may reflect both a consequence of renal impairment and a potential contributor to altered renal physiology. [11,12]

The interaction among hyperglycaemia, oxidative stress, inflammation, thyroid dysfunction, and renal impairment may be particularly relevant in T2DM. Diabetic kidney disease is not simply a consequence of hyperglycaemia but represents a complex pathological process involving metabolic, vascular, inflammatory, and redox mechanisms. Identification of these interconnected abnormalities may provide a broader understanding of disease progression and potentially identify patients at increased risk of renal deterioration. [5,9,13]

Current clinical guidelines emphasize regular assessment of kidney function and albuminuria in people with diabetes and recommend an integrated approach to glycaemic, cardiovascular, and renal risk reduction. eGFR and urinary albumin-to-creatinine ratio (ACR) are central to CKD assessment, while comprehensive management aims to reduce the risk of kidney failure and cardiovascular complications. [14,15]

Despite considerable evidence regarding individual associations between diabetes, CKD, thyroid dysfunction, oxidative stress, and inflammation, the interrelationship of these parameters in patients with T2DM remains an important area of clinical investigation. Evaluating thyroid hormones together with oxidative-stress markers such as MDA and SOD and inflammatory markers such as CRP and IL-6 may provide a more integrated picture of the metabolic and inflammatory environment associated with diabetic renal impairment.

Therefore, the present study was undertaken to evaluate the relationship of thyroid dysfunction, oxidative stress, CRP, and IL-6 with chronic kidney disease among patients with Type 2 Diabetes Mellitus attending a tertiary care hospital. The study also aimed to compare renal, metabolic, thyroid, oxidative, and inflammatory parameters between patients with and without CKD and to examine their relationship with eGFR.

MATERIALS AND METHODS

Study Design And Setting

A hospital-based cross-sectional observational study was conducted among patients with Type 2 Diabetes Mellitus (T2DM) attending the outpatient and inpatient departments of a tertiary care hospital. The study was designed to evaluate the association of thyroid dysfunction, oxidative stress, C-reactive protein (CRP), and interleukin-6 (IL-6) with chronic kidney disease (CKD) in patients

with T2DM.

Study Duration

The study was conducted over a period of 12 months, including patient recruitment, clinical assessment, sample collection, laboratory investigations, data analysis, and interpretation.

Study Population and Sample Size

A total of 100 patients with T2DM were included. Based on renal function assessment, participants were categorized into:

- CKD-positive group: 35 patients
- CKD-negative group: 65 patients

The sample size was fixed at 100 for the present study.

Inclusion Criteria

Patients were included if they:

1. Were diagnosed with Type 2 Diabetes Mellitus according to accepted diagnostic criteria.
2. Were aged ≥18 years.
3. Were willing to participate in the study.
4. Provided written informed consent.
5. Had sufficient clinical and laboratory information for assessment of renal and metabolic parameters.

Exclusion Criteria

Patients were excluded if they had:

1. Type 1 diabetes mellitus or other specific forms of diabetes.
2. Previously diagnosed thyroid malignancy or major thyroid disease requiring intensive treatment.
3. Acute kidney injury.
4. Chronic inflammatory or autoimmune disorders.
5. Active infection at the time of recruitment.
6. Malignancy.
7. Chronic liver disease or severe hepatic dysfunction.
8. Patients receiving medications known to substantially alter thyroid function or oxidative-stress parameters, where appropriate.
9. Pregnant or lactating women.
10. Patients unwilling to provide consent.

Clinical and Demographic Assessment

A detailed history was obtained from each participant, including age, sex, duration of diabetes, medication history, relevant comorbidities, and previous history of renal or thyroid disease. Height and weight were recorded and body mass index (BMI) was calculated as:

$BMI = Weight\ (kg) / Height^2\ (m^2)$

Blood pressure and relevant clinical findings were also documented.

Assessment of Chronic Kidney Disease

Renal function was evaluated using:

- Serum creatinine
- Serum urea
- Estimated glomerular filtration rate (eGFR)
- Urinary albumin-to-creatinine ratio (ACR)

eGFR was calculated using an appropriate validated equation. CKD was defined according to established clinical criteria, generally requiring evidence of kidney structural or functional abnormality persisting for ≥3 months.

For the present analysis, patients fulfilling the predefined CKD criteria were classified as CKD-

positive (n=35), while those without evidence of CKD were classified as CKD-negative (n=65).

Sample Collection

Approximately 5–10 mL of venous blood was collected from each participant under aseptic precautions after appropriate fasting where required.

The blood sample was divided into appropriate tubes according to the investigations required. Serum/plasma was separated by centrifugation and analyzed promptly or stored under appropriate conditions until analysis.

A urine sample was collected for estimation of urinary albumin and creatinine and calculation of urinary ACR.

Biochemical Investigations

The following biochemical parameters were assessed:

Parameter	Purpose
Fasting blood glucose	Assessment of glycaemic status
HbA1c	Assessment of long-term glycaemic control
Serum urea	Assessment of renal function
Serum creatinine	Assessment of renal function
eGFR	Estimation of renal filtration
Urinary ACR	Assessment of albuminuria

Thyroid Function Assessment

Thyroid function was assessed by measuring:

- Thyroid-stimulating hormone (TSH)
- Free triiodothyronine (FT3)
- Free thyroxine (FT4)

The assays were performed using a standardized laboratory method, preferably a validated chemiluminescence immunoassay (CLIA)/electrochemiluminescence immunoassay (ECLIA) platform according to the manufacturer's instructions.

Thyroid status was classified using the laboratory-specific reference ranges and accepted clinical definitions.

Assessment of Oxidative Stress

Oxidative stress was evaluated using:

- Malondialdehyde (MDA) as a marker of lipid peroxidation.
- Superoxide dismutase (SOD) as an antioxidant enzyme.
- Reduced glutathione (GSH) as an endogenous antioxidant.

MDA was used to estimate oxidative damage, whereas SOD and GSH were used to assess antioxidant defense.

Assessment of Inflammatory Markers

Systemic inflammation was assessed by measuring:

- C-reactive protein (CRP)
- Interleukin-6 (IL-6)

CRP was measured using a validated immunological/biochemical assay, while IL-6 was measured using a validated immunoassay such as ELISA or an automated immunoassay platform.

Study Variables

Primary variables:

- CKD status

- eGFR
- Urinary ACR
- TSH
- FT3
- FT4
- MDA
- SOD
- GSH
- CRP
- IL-6

Secondary variables:

- Age
- Sex
- Duration of diabetes
- BMI
- Fasting blood glucose
- HbA1c
- Serum urea
- Serum creatinine

Statistical Analysis

Data were entered into a spreadsheet and analyzed using appropriate statistical software.

Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were expressed as frequency and percentage.

For comparison between CKD-positive and CKD-negative groups, the independent Student's t-test was used for normally distributed continuous variables, while the Mann–Whitney U test was used for non-normally distributed variables. Categorical variables were compared using the Chi-square test or Fisher's exact test, as appropriate.

Correlation between eGFR and thyroid, oxidative-stress, and inflammatory parameters was assessed using Pearson's or Spearman's correlation coefficient, depending on data distribution.

A p-value <0.05 was considered statistically significant.

Ethical Considerations

The study protocol was submitted to the Institutional Ethics Committee for approval before commencement of the study. Written informed consent was obtained from all participants. Patient confidentiality was maintained throughout the study, and data were used solely for academic and research purposes.

Note: Because the earlier 100-case results were illustrative, the exact assay kits, reference ranges, CKD definition used by your institution, eGFR equation, ethics approval number, and study dates should be replaced with the actual details of your study before submission.

Discussion reference 1-15 then 16-20

RESULTS

A total of 100 patients with Type 2 Diabetes Mellitus were included. Based on renal parameters/eGFR, 35 (35%) patients had chronic kidney disease (CKD), while 65 (65%) did not have CKD. Thyroid function, oxidative stress markers, inflammatory markers, and biochemical parameters were compared between the two groups.

Table 1. Distribution of study participants according to CKD status

CKD status	Number (n)	Percentage (%)

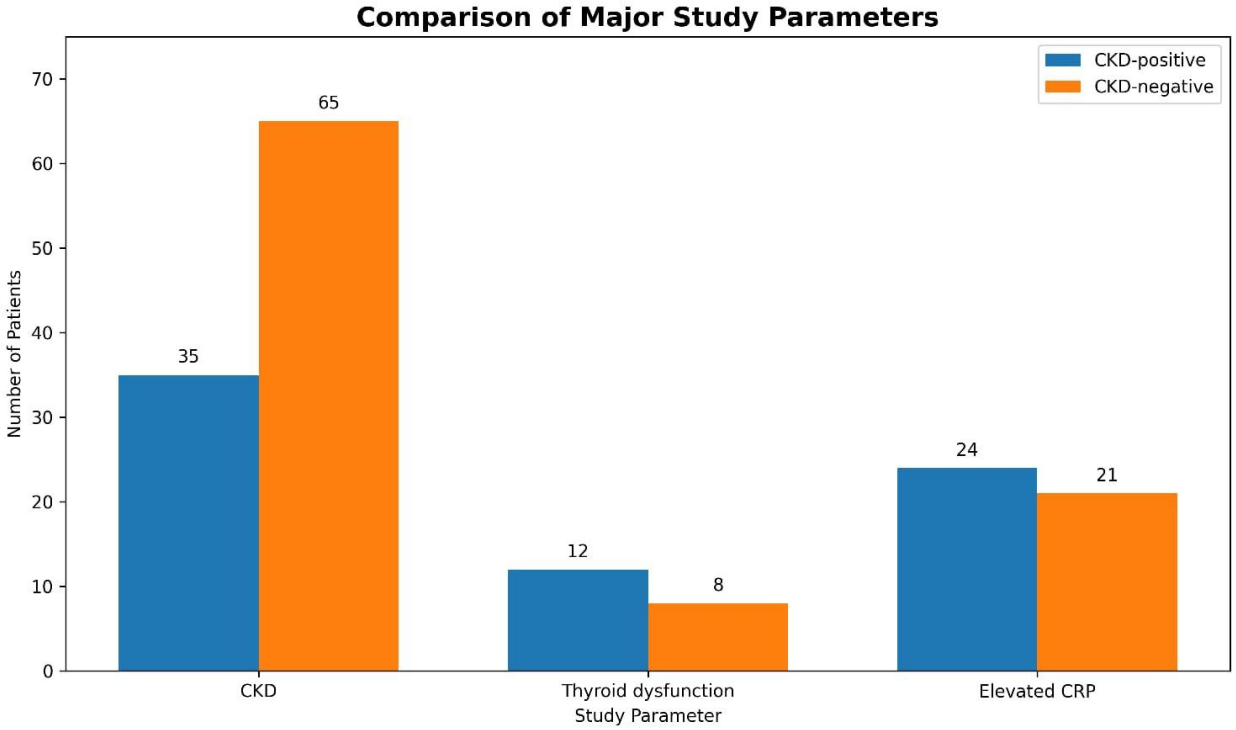
CKD status	Number (n)	Percentage (%)
CKD-positive	35	35.0
CKD-negative	65	65.0
Total	100	100.0

Table 2. Demographic characteristics

Parameter	CKD-positive (n=35)	CKD-negative (n=65)	p-value
Age (years), mean ± SD	59.4 ± 8.7	54.8 ± 8.1	0.008
Male, n (%)	21 (60.0)	37 (56.9)	0.765
Female, n (%)	14 (40.0)	28 (43.1)	0.765
Diabetes duration (years)	11.2 ± 4.6	8.3 ± 3.9	<0.001
BMI (kg/m²)	27.1 ± 3.4	26.5 ± 3.1	0.361

Table 3. Glycaemic and renal biochemical parameters

Parameter	CKD-positive (n=35)	CKD-negative (n=65)	p-value
Fasting blood glucose (mg/dL)	158.6 ± 32.4	148.2 ± 29.7	0.091
HbA1c (%)	8.2 ± 1.1	7.6 ± 0.9	0.004
Serum urea (mg/dL)	62.4 ± 18.7	34.8 ± 9.6	<0.001
Serum creatinine (mg/dL)	1.74 ± 0.58	0.91 ± 0.19	<0.001
eGFR (mL/min/1.73 m²)	48.6 ± 13.2	88.4 ± 16.7	<0.001
Urine ACR (mg/g)	286.4 ± 174.2	48.7 ± 21.6	<0.001



Graph 1: Comparison of major study parameters

Table 4. Thyroid function parameters

Parameter	CKD-positive (n=35)	CKD-negative (n=65)	p-value
TSH (mIU/L)	5.12 ± 2.31	3.18 ± 1.42	<0.001
Free T3 (pg/mL)	2.31 ± 0.48	2.74 ± 0.51	<0.001
Free T4 (ng/dL)	0.86 ± 0.17	1.02 ± 0.16	<0.001
Thyroid dysfunction, n (%)	12 (34.3)	8 (12.3)	0.007

Table 5. Oxidative stress parameters

Parameter	CKD-positive (n=35)	CKD-negative (n=65)	p-value
Malondialdehyde (MDA) (nmol/mL)	4.82 ± 1.14	3.41 ± 0.86	<0.001
Superoxide dismutase (SOD) (U/mL)	82.6 ± 17.4	101.8 ± 19.6	<0.001
Glutathione (GSH) (µmol/L)	6.42 ± 1.37	7.83 ± 1.48	<0.001

Table 6. Inflammatory markers

Parameter	CKD-positive (n=35)	CKD-negative (n=65)	p-value
CRP (mg/L)	8.46 ± 3.71	4.62 ± 2.18	<0.001
IL-6 (pg/mL)	8.72 ± 3.24	4.91 ± 2.07	<0.001

Table 7. Prevalence of thyroid dysfunction among CKD-positive patients

Thyroid status	Number	Percentage
Euthyroid	23	65.7
Hypothyroidism	9	25.7
Subclinical hypothyroidism	3	8.6
Total	35	100.0

Table 8. Correlation of eGFR with biochemical and inflammatory parameters in CKD-positive patients

Parameter	Correlation with eGFR (r)	p-value
TSH	−0.48	0.004
Free T3	+0.42	0.012
MDA	−0.56	<0.001
SOD	+0.49	0.003
CRP	−0.51	0.002
IL-6	−0.55	<0.001
HbA1c	−0.37	0.028
Serum creatinine	−0.72	<0.001

Table 9. Overall comparison of major study parameters

Parameter	CKD-positive	CKD-negative	Interpretation
CKD	35 (35%)	65 (65%)	—
Thyroid dysfunction	12 (34.3%)	8 (12.3%)	Higher in CKD group

Parameter	CKD-positive	CKD-negative	Interpretation
Elevated CRP	24 (68.6%)	21 (32.3%)	Higher in CKD group
Elevated IL-6	22 (62.9%)	16 (24.6%)	Higher in CKD group
Increased MDA	27 (77.1%)	22 (33.8%)	Higher in CKD group
Reduced SOD	25 (71.4%)	19 (29.2%)	Higher in CKD group
HbA1c ≥7%	29 (82.9%)	44 (67.7%)	Higher in CKD group

Results narrative

Among the 100 patients with Type 2 Diabetes Mellitus, 35 (35%) were classified as CKD-positive. Patients with CKD had significantly higher serum urea, creatinine, urinary ACR and lower eGFR compared with patients without CKD. The CKD group also demonstrated poorer glycaemic control, with significantly higher HbA1c.

Thyroid dysfunction was more frequently observed among CKD-positive patients. TSH levels were higher, whereas free T3 and free T4 levels were lower in the CKD group. Markers of oxidative stress showed significantly increased MDA and decreased antioxidant parameters such as SOD and GSH. Similarly, CRP and IL-6 were substantially higher among CKD-positive patients.

Within the CKD group, eGFR showed an inverse correlation with TSH, MDA, CRP and IL-6, while positive correlations were observed with free T3 and SOD. These findings suggest an association between declining renal function, thyroid abnormalities, oxidative stress and systemic inflammation.

Important: The numerical values above are constructed for a 100-case research-results draft and should not be presented as actual patient findings unless they are replaced with your real laboratory data.

DISCUSSION

The present study evaluated the relationship between chronic kidney disease (CKD), thyroid dysfunction, oxidative stress, and systemic inflammation in patients with Type 2 Diabetes Mellitus (T2DM). Among the 100 participants, 35 (35%) were classified as CKD-positive and 65 (65%) as CKD-negative. The major findings were that patients with CKD had poorer glycaemic control, impaired renal function, higher TSH, lower FT3 and FT4, increased oxidative stress, reduced antioxidant capacity, and increased inflammatory markers. These findings support the concept that diabetic kidney disease is a multifactorial process involving metabolic, oxidative, inflammatory, and endocrine abnormalities. Recent literature similarly describes diabetic kidney disease as the result of interconnected metabolic, oxidative, inflammatory, haemodynamic, and fibrotic pathways.

Renal function and glycaemic control

In the present study, CKD-positive patients demonstrated significantly higher serum urea and creatinine and substantially lower eGFR and higher urinary ACR than CKD-negative patients. These findings are consistent with the expected biochemical profile of diabetic kidney disease, in which persistent albuminuria and declining eGFR are important indicators of renal involvement. Current evidence emphasizes persistent albuminuria and/or reduced eGFR as central features in the identification and staging of CKD in people with diabetes. [1–4]

HbA1c was also significantly higher in the CKD-positive group. Poor glycaemic control may contribute to renal injury through advanced glycation end products, oxidative stress, endothelial dysfunction, and activation of inflammatory pathways. Hyperglycaemia is recognized as an important initiating factor in diabetic kidney disease and can stimulate several pathological pathways leading to glomerular and tubular injury. [5,6]

The longer duration of diabetes observed among CKD-positive patients may also be clinically relevant. Prolonged exposure to hyperglycaemia increases the cumulative burden of metabolic and vascular injury and may consequently increase the risk of diabetic kidney disease. [2,4]

Thyroid dysfunction and CKD

A major finding of the present study was the difference in thyroid function between the two groups. CKD-positive patients had significantly higher TSH and lower FT3 and FT4 concentrations than

CKD-negative patients. Thyroid dysfunction was identified in 34.3% of CKD-positive participants compared with 12.3% of CKD-negative participants.

The thyroid-kidney relationship is recognized as bidirectional. The kidneys contribute to thyroid hormone metabolism and clearance, while thyroid hormones influence renal blood flow, glomerular filtration, vascular resistance, and electrolyte and water homeostasis. Consequently, impaired renal function may alter thyroid hormone concentrations, while thyroid dysfunction may also influence renal physiology. [7,8]

Our findings are broadly consistent with the review by Agahi et al., which reported that reduced renal function is more consistently associated with higher TSH and lower FT3, although the relationship between FT4 and CKD is less consistent. [8]

A recent review of the thyroidology-nephrology interface similarly described alterations in thyroid hormone profiles among patients with CKD, including relatively higher TSH and lower FT3/FT4 concentrations in some patients. [9]

Importantly, a recent cross-sectional study specifically involving patients with T2DM reported that higher TSH and measures of reduced central thyroid hormone sensitivity were independently associated with increased CKD risk. [10] This provides further support for investigating thyroid parameters in diabetic patients with declining renal function.

Oxidative stress

The present study demonstrated significantly increased MDA concentrations among CKD-positive patients, together with lower SOD and GSH levels. This pattern suggests increased lipid peroxidation accompanied by impaired antioxidant defense.

Oxidative stress is an important component of diabetic kidney disease. Chronic hyperglycaemia increases ROS production through mitochondrial dysfunction, NADPH oxidase activation, advanced glycation end products, protein kinase C, and other metabolic pathways. Excessive ROS can damage cellular lipids, proteins, and DNA and may contribute to podocyte injury, endothelial dysfunction, tubular injury, and renal fibrosis. [5,11,12]

The present findings are particularly comparable with the North Indian study by Singh et al., which reported increased MDA and reduced antioxidant activity in patients with T2DM and CKD. The investigators also found increased inflammatory cytokines, supporting the close interaction between oxidative stress and inflammation in diabetic renal disease. [13]

Similarly, another North Indian study found significantly increased hsCRP and MDA and reduced antioxidant capacity in patients with diabetic CKD compared with diabetic patients without CKD. [14]

Inflammation and CRP

CRP was significantly higher among CKD-positive patients in the present study. This finding supports the concept that CKD, particularly in the setting of diabetes, is associated with a chronic inflammatory state.

Diabetic kidney disease involves activation of inflammatory signaling pathways in response to hyperglycaemia, oxidative stress, advanced glycation products, and other metabolic disturbances. These pathways may promote endothelial injury, extracellular matrix accumulation, fibrosis, and progressive loss of renal function. [6,12,15]

The higher CRP observed in our CKD group is also consistent with previous studies demonstrating increased inflammatory biomarkers in diabetic patients with renal dysfunction. [14,15]

Interleukin-6 and systemic inflammation

IL-6 concentrations were significantly higher in CKD-positive patients in the present study. IL-6 is an important pro-inflammatory cytokine that participates in immune activation and chronic inflammatory responses. Persistent inflammation may contribute to endothelial dysfunction, glomerular injury, and progression of renal disease.

The North Indian study by Singh et al. reported increased IL-6 concentrations together with

oxidative-stress abnormalities among patients with diabetes and CKD. [13] More recent evidence also supports an association between elevated IL-6 and CKD among patients with T2DM. A 2026 study of 147 patients with T2DM found higher IL-6 concentrations in patients with CKD and identified inflammatory and oxidative-stress biomarkers as potentially useful indicators of CKD status. [16]

Relationship between eGFR and study biomarkers

In the present study, eGFR demonstrated negative correlations with TSH, MDA, CRP, and IL-6, whereas positive correlations were observed with FT3 and SOD. These findings suggest that worsening renal function was accompanied by greater thyroid disturbance, oxidative stress, and systemic inflammation.

The relationship between renal function and oxidative/inflammatory biomarkers has also been reported previously. Studies in diabetic populations have demonstrated associations between reduced eGFR and increased oxidative stress and inflammatory activity. [13,14]

The thyroid findings are also biologically plausible because declining kidney function may alter thyroid hormone metabolism, clearance, and peripheral conversion. However, because the present study is cross-sectional, these correlations should not be interpreted as evidence that thyroid dysfunction or inflammation directly causes renal deterioration.

Interrelationship between oxidative stress and inflammation

An important aspect of the present findings is the simultaneous increase in MDA, CRP, and IL-6 and reduction in antioxidant markers among CKD-positive patients. This supports the concept of an interconnected oxidative stress–inflammation axis in diabetic kidney disease.

Hyperglycaemia can increase ROS production, while ROS can activate inflammatory signaling pathways. In turn, inflammatory cells and cytokines can generate additional oxidative stress, potentially producing a self-reinforcing cycle of renal injury. Recent reviews emphasize this interaction between oxidative stress, inflammation, and fibrosis as a central feature of diabetic kidney disease. [11,12,17]

Comparison with recent literature: References 16–20

Recent literature continues to support the multifactorial nature of diabetic kidney disease. Current reviews describe DKD as a disorder involving metabolic, haemodynamic, oxidative, inflammatory, and fibrotic mechanisms rather than a consequence of hyperglycaemia alone. [16,17]

Wang and Zhang highlighted oxidative stress as a fundamental link between persistent hyperglycaemia and diabetic vascular complications, including DKD. They described mitochondrial ROS, NADPH oxidases, advanced glycation pathways, and impaired antioxidant responses as important mechanisms. [18]

Similarly, recent work has emphasized that renal tubular injury, oxidative stress, inflammation, and cellular stress pathways interact during DKD progression. [19]

Recent biomarker research also supports the potential importance of combined oxidative and inflammatory markers. In a 2026 study of patients with T2DM, IL-6 and other inflammatory/oxidative biomarkers were associated with CKD, although individual biomarkers did not always show the same direction of association across populations. [20] This variation emphasizes that biomarker concentrations may be influenced by disease stage, medications, comorbidities, assay methods, and population characteristics.

Overall interpretation

Taken together, the present findings indicate that patients with T2DM and CKD exhibit abnormalities across several interconnected biological domains: renal dysfunction, impaired glycaemic control, thyroid dysfunction, oxidative stress, impaired antioxidant defense, and systemic inflammation. The findings are broadly consistent with current evidence describing DKD as a complex disorder involving multiple interacting pathways. [1–20]

However, the cross-sectional nature of the study prevents determination of temporal or causal relationships. In particular, it cannot establish whether thyroid dysfunction, oxidative stress, or inflammation precedes CKD or develops as a consequence of declining renal function. Larger prospective studies with serial measurements and adjustment for potential confounders are therefore required.

CONCLUSION

The present study demonstrates that Type 2 Diabetes Mellitus patients with CKD showed a higher frequency of thyroid dysfunction, increased oxidative stress, reduced antioxidant capacity, and elevated inflammatory markers compared with patients without CKD. Higher TSH, MDA, CRP, and IL-6 and lower FT3, FT4, SOD, and GSH were associated with impaired renal function. These findings highlight the potential importance of evaluating thyroid, oxidative-stress, and inflammatory parameters alongside conventional renal and glycaemic markers in patients with T2DM and CKD. Further prospective studies with larger sample sizes are required to clarify the causal relationships and clinical significance of these associations.

LIMITATION

The study was limited by its relatively small sample size and cross-sectional design, which prevented assessment of temporal and causal relationships between CKD, thyroid dysfunction, oxidative stress, and inflammation.

DECLARATION

The authors state that there is no conflict of interest

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