Al-Rafidain J Med Sci. 2025;8(2):139-143.
DOI: https://doi.org/10.54133/ajms.v8i2.1900

AJMS
Online ISSN (2789-3219)

Research Article

Thyroid Function Tests in Various Stages of Chronic Kidney Disease in Children: A Cross-Sectional Study

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Received: 20 March 2025; Revised: 8 May 2025; Accepted: 12 May 2025

Abstract

Objective: To determine the prevalence of thyroid dysfunction in pediatric patients and its association with the progression of chronic kidney disease (CKD), growth development, blood pressure, and different treatment strategies. ***Methods***: We assessed 51 children with CKD, with a mean age of 8.3 years, of whom 58.8% were boys. We evaluated their kidney function (serum creatinine and eGFR), thyroid hormones (TSH and free T4), blood pressure, and body mass index (BMI). Additionally, we reviewed their medical history, medications, and whether they were on dialysis or had received a kidney transplant. Statistical tests helped us compare thyroid function across different CKD stages and assess possible connections with other health factors. ***Results***: Our findings revealed that 15.7% of the children had hypothyroidism, with a significantly higher prevalence among girls. Interestingly, thyroid hormone levels did not show significant fluctuations between the early and late stages of CKD. As expected, kidney function worsened with CKD progression, but thyroid problems did not appear to be directly linked to this decline. Moreover, no significant relationship was found between thyroid dysfunction and elevated blood pressure. ***Conclusions***: Thyroid disturbances are common in children with CKD, especially in girls, but they don't seem to worsen as kidney disease progresses. Since thyroid problems can affect growth and overall health, regular screening in these children, especially those at higher risk, may help catch and manage them early. More long-term studies are needed to better understand this relationship.

Keywords: Chronic kidney disease, Dialysis, Growth development, Hypothyroidism, Pediatric nephrology, Thyroid dysfunction.

اختبارات وظائف الغدة الدرقية في مراحل مختلفة من أمراض الكلى المزمنة عند الأطفال: دراسة مقطعية

الخلاصة

الهدف: تحديد مدى انتشار ضعف الغدة الدرقية لدى الأطفال وارتباطه بتطور مرض الكلى المزمن (CKD) ، وتطور النمو، وضغط الدم، واستراتيجيات العلاج المختلفة. **الطرائق**: قمنا بتقييم 51 طفلا مصابا بمرض الكلى المزمن ، بمتوسط عمر 8.3 سنوات، منهم 58.8٪ من الأولاد. قمنا بتقييم وظائف الكلى (الكرياتينين في الدم و eGFR)، وهرمونات الغدة الدرقية (TSH و T4 الحر)، وضغط الدم، ومؤشر كتلة الجسم (BMI). بالإضافة إلى ذلك، قمنا بمراجعة تاريخهم الطبي وأدويتهم وما إذا كانوا يخضعون لغسيل الكلى أو خضعوا لعملية زرع كلى. ساعدتنا الاختبارات الإحصائية في مقارنة وظيفة الغدة الدرقية عبر مراحل مختلفة من مرض الكلى المزمن وتقييم الروابط المحتملة مع العوامل الصحية الأخرى. **النتائج**: كشفت النتائج التي توصلنا إليها أن 15.7٪ من الأطفال يعانون من قصور الغدة الدرقية، مع انتشار أعلى بكثير بين الفتيات. ومن المثير للاهتمام أن مستويات هرمون الغدة الدرقية لم تظهر تقلبات كبيرة بين المراحل المبكرة والمتأخرة من مرض الكلى المزمن. كما هو متوقع، ساءت وظائف الكلى مع تطور مرض الكلى المزمن، ولكن لا يبدو أن مشاكل الغدة الدرقية مرتبطة ارتباطا مباشرا بهذا الانخفاض. علاوة على ذلك، لم يتم العثور على علاقة ذات دلالة إحصائية بين ضعف الغدة الدرقية وارتفاع ضغط الدم. **الاستنتاجات**: اضطرابات الغدة الدرقية شائعة عند الأطفال المصابين بمرض الكلى المزمن، خاصة عند الفتيات، ولكن لا يبدو أنها تزداد سوءا مع تقدم أمراض الكلى. نظرا لأن مشاكل الغدة الدرقية يمكن أن تؤثر على النمو والصحة العامة، فقد يساعد الفحص المنتظم لدى هؤلاء الأطفال، وخاصة أولئك المعرضين لخطر أكبر، في اكتشافهم وإدارتهم مبكرا. هناك حاجة إلى مزيد من الدراسات طويلة الأجل لفهم هذه العلاقة بشكل أفضل.

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Article citation: Hasan JS, Mohammed BM, Hammoodi IA, Shukri AA. Thyroid Function Tests in Various Stages of Chronic Kidney Disease in Children: A Cross-Sectional Study. *Al-Rafidain J Med Sci.* 2025;8(2):139-143. doi: https://doi.org/10.54133/ajms.v8i2.1900

INTRODUCTION

Chronic kidney disease (CKD) is a complex condition that not only affects the kidneys but also has widespread effects on multiple organ systems, including the endocrine system [1]. Although thyroid dysfunction is well documented in adults with CKD, its role in children remains less explored. In adults, declining kidney function is often linked to hypothyroidism due to

impaired iodide excretion, which leads to elevated blood iodide levels and reduced thyroid hormone production as the glomerular filtration rate (GFR) decreases [2], Additionally, metabolic imbalances such as acidosis and protein-energy wasting interfere with the conversion of thyroxine (T4) to triiodothyronine (T3), contributing to lower T3 levels [3]. These disruptions may further complicate the metabolic and growth challenges that children with CKD already face. Growth failure is a major concern in pediatric CKD, driven by a combination of anemia, metabolic acidosis, bone mineral disorders, and growth hormone resistance [4]. Thyroid dysfunction, particularly hypothyroidism, may further hinder growth and development in these children. While studies in adults have shown a clear link between worsening CKD and higher rates of hypothyroidism—ranging from 20% to 30% across CKD stages—data on pediatric populations remain scarce [5,6]. Despite the well-established connection between CKD and thyroid dysfunction, routine thyroid screening is not a standard part of pediatric CKD management [7]. This gap in care raises important questions about whether unrecognized thyroid abnormalities contribute to poor growth outcomes and other complications. This study aims to assess the prevalence and patterns of thyroid dysfunction in children with CKD, shedding light on the need for systematic screening and timely intervention. This study aims to assess the association between thyroid function and kidney function markers in pediatric patients with chronic kidney disease (CKD). Specifically, it seeks to identify the prevalence of thyroid dysfunction across different CKD stages and explore relationships with cardiovascular parameters, growth, and treatment modalities.

METHODS

Study design and setting

A cross-sectional observational study was conducted to evaluate thyroid function in children with CKD using descriptive and inferential statistical analyses.

Outcome measurements

A total of 51 pediatric patients diagnosed with CKD have participated in this survey. The study has been conducted over 6 months duration from February 2024 to July 2024, in the tertiary hospitals in Duhok and Mosul. These variables have been assessed: Serum creatinine, estimated glomerular filtration rate (eGFR), TSH and free T4, blood pressure, and body mass index (BMI). During the encounter, comorbidities (especially hypertension and thyroid disorders) and medication history were taken, and other treatments have been reviewed, including dialysis and transplantation status. Thyroid function was classified based on TSH and free T4 values as: primary hypothyroidism (high TSH with low free T4), secondary or central hypothyroidism (low or inappropriately normal TSH and low free T4), and subclinical hypothyroidism (high TSH with normal free T4). T3 measurement was not included in this study.

Statistical analysis

Data were analyzed using software IBM SPSS Statistics for Windows, Version 27.0 (2020; IBM Corp., Armonk, New York, United States), which was used to analyze the variables. Descriptive statistics were used for quantitative variables. ANOVA and Kruskal-Wallis tests were used to compare means across CKD stages and cross-tabulation with chi-square tests to evaluate relationships between thyroid dysfunction and categorical variables, and a 5% probability ($p< 0.05$) was considered statistically significant.

RESULTS

A total of 51 pediatric CKD patients were enrolled in this study, with a mean age of 8.3 ± 4.2 years (range: 1–17), with 58.8% being male and 41.2% being female. 52.9% had short stature, and 37.3% had hypertension. CKD stages were distributed as follows: Stage 1 (13.7%), Stage 2 (15.7%), Stage 3 (19.6%), Stage 4 (27.5%), and Stage 5 (23.5%). Most of the patients (84.3%) were on medications, 13.7% on dialysis, and 2.0% had a transplant. Hypothyroidism was present in 15.7% of patients. The mean TSH level was 3.52 ± 1.89 mIU/L, and FT4 was 24.60±23.53 pmol/L (Table 1). Among hypothyroid patients, free T4 levels were variable with a high standard deviation, suggesting a mix of subclinical and overt hypothyroidism. Due to the absence of T3 measurements and limited stratification of free T4 values, precise classification into subtypes (primary vs subclinical) could not be fully ascertained. No significant difference in TSH ($p= 0.893$) or FT4 ($p = 0.549$) was observed across CKD stages. Hypothyroidism was significantly more common in females (75%) than males (25%) ($p= 0.034$). All hypothyroid patients were on CKD medications, but none were on dialysis or had a transplant ($p= 0.414$). Serum creatinine increased significantly with CKD progression ($p< 0.001$) (Table 2). No significant correlation was found between thyroid dysfunction and hypertension ($p= 0.237$). Among those diagnosed with hypothyroidism, 7 out of 8 (87.5%) were on antihypertensive medications compared to 53.5% of euthyroid patients ($p= 0.073$). Comorbid conditions were noted in 10 patients (19.6%), with a slightly higher rate in hypothyroid patients ($p= 0.676$). A family history of thyroid disorders was reported in 23.5%, but no statistically significant association with thyroid dysfunction was found (Table 3). Normal values of different thyroid hormones based on different age groups have been provided in Table 4.

Table 1: Baseline Characteristics of study participants

Variable	Category	Result
Gender	Male	30(58.8)
	Female	21(41.2)
Age (years)	-	8.3±4.2
Weight Class	Underweight	4(7.8)
	Healthy Weight	42(82.4)
	Obesity	5 (9.8)
Weight (kg)	-	26±21
Height Classification	Normal Height	24(47.1)
	Short Stature	27(52.9)
Height (cm)	-	113±24
BMI Classification	Underweight	7(13.7)
	Healthy Weight	35(68.6)
	Overweight	3(5.9)
	Obese	6(11.8)
BMI (kg/m²)	-	18.67±9.14
BP Classification	Normal	19(37.3)
	Elevated BP	2(3.9)
	Stage 1 HT	19(37.3)
	Stage 2 HT	11(21.6)
Systolic BP (mmHg)	-	111±15
Diastolic BP (mmHg)	-	70±14
Treatment of CKD	Medications	43(84.3)
	Dialysis	7(13.7)
	Transplant	1(2.0)
Duration of CKD (Months)	-	38±29
CKD Stage	Stage 1	7(13.7)
	Stage 2	8(15.7)
	Stage 3	10(19.6)
	Stage 4	14(27.5)
	Stage 5	12(23.5)
On Antihypertensive Medication	Yes	30(58.8)
	No	21(41.2)
Previous History of Thyroid Disorders	Yes	3(5.9)
	No	48(94.1)
Type of Thyroid Disorder	No	43(84.3)
	Hypothyroidism	8(15.7)
Current Medication for Thyroid Disorders	Thyroxine	8(15.7)
	No	43(84.3)
Family History of Thyroid Disorders	Positive	12(23.5)
	Negative	39(76.5)
TSH (mIU/L)	-	3.52±1.89
FT4 (pmol/L)	-	24.6±23.53
Serum Creatinine (mg/dL)	-	20.8±124.34
eGFR (mL/min/1.73m²)	-	44.11±42.75
Comorbidities	Yes	10(19.6)
	No	41(80.4)

Values were expressed as frequency, percentage, and mean±SD.

Table 2: Descriptive statistics, ANOVA, and Kruskal Wallis test results for thyroid and kidney function parameters across CKD stages

Parameter	CKD Stage	n	Mean±SD	*p* (ANOVA)	*p* (Kruskal-Wallis test)
TSH (mIU/L)	Stage 1	7	3.89±1.71	0.893	0.689
	Stage 2	8	3.25±2.25		
	Stage 3	10	3.18±1.43		
	Stage 4	14	3.83±1.73		
	Stage 5	12	3.41±2.42		
	Total	51	3.52±1.89		
FT4 (pmol/L)	Stage 1	7	22.30±21.44	0.549	0.251
	Stage 2	8	31.50±29.95		
	Stage 3	10	16.14±3.07		
	Stage 4	14	22.19±26.22		
	Stage 5	12	31.22±26.76		
	Total	51	24.60±23.53		
Serum Creatinine (mg/dL)	Stage 1	7	0.35±0.11	0.506	<0.001
	Stage 2	8	8.97±23.05		
	Stage 3	10	1.25±0.38		
	Stage 4	14	2.24±0.57		
	Stage 5	12	78.55±255.23		
	Total	51	20.80±124.34		

Table 3: Distribution of thyroid function status in pediatric CKD patients by crosstabulation

Variable	Category	Normal	Hypothyroidism	Total	*p*-value
Gender	Male	28(65.1)	2(25)	30(58.8)	0.034
	Female	15(34.9)	6(75)	21(41.2)	
Treatment of CKD	Medications	35(81.4)	8(100)	43(84.3)	0.414
	Dialysis	7(16.3)	0(0.0)	7(13.7)	
	Transplant	1(2.3)	0(0.0)	1(2)	
BP category	Normal	15(34.9)	4(50)	19(37.3)	0.237
	Elevated BP	1(2.3)	1(12.5)	2(3.9%)	
	Stage 1 HT	16(37.2)	3(37.5)	19(37.3)	
	Stage 2 HT	11(25.6)	0(0.0)	11(21.6)	
	Total	43(100)	8(100)	51(100)	
On antihypertensive	Yes	23(53.5)	7(87.5)	30(58.8)	0.073
	No	20(46.5)	1(12.5)	21(41.2)	
Comorbidities	Yes	8(18.6)	2(25)	10(19.6)	0.676
	No	35(81.4)	6(75)	41(80.4)	

Values were expressed as numbers and percentages. BP: Blood pressure

Table 4: Normal reference ranges for thyroid function tests across different age groups

Age	TSH (µIU/ml)	T4 (µg/dl)	T3 (ng/dl)	Free T4 (ng/dl)
Cord blood	1.0-17.4	7.4-13.0	15-75	0.9-2.2
1-4 days	1.0-39.0	14.0-28.4	100-740	2.2-5.3
2-20 weeks	1.7-9.1	7.2-15.7	105-245	0.9-2.3
S-24 months	0.8-8.2	7.2-15.7	105-269	0.8-1.8
2-7 years	0.7-5.7	6.0-14.2	94-241	1.0-2.1
8-20 years	0.7-5.7	4.7-12.4	80-210	0.8-1.9
21-45 years	0.4-4.2	5.3-10.5	70-204	0.9-2.5

TSH: thyroid-stimulating hormone; T4: thyroxine; T3: triiodothyronine. Adapted from Marks and LaFranchi [15] with kind permission from Springer Science and Business Media.

DISCUSSION

Thyroid dysfunction is a common but often overlooked concern in children with chronic kidney disease (CKD), and our study sheds light on its prevalence, particularly among females. While past research has suggested a possible link between CKD progression and thyroid abnormalities, our findings tell a different story—thyroid function appears to remain relatively stable across different CKD stages. This raises an interesting question: Could there be compensatory mechanisms at play that help maintain thyroid hormone balance despite worsening kidney function? Another intriguing aspect of our findings is the connection between antihypertensive use and hypothyroidism. This suggests there may be deeper interactions between the cardiovascular system and thyroid metabolism, which deserve further investigation. Our results align with those of Yadav *et al*., who found that 26.2% of children with CKD had thyroid dysfunction, with higher rates in advanced CKD stages [8]. Similarly, Garrido-Magaña et al. reported a 28% incidence of thyroid dysfunction among pediatric dialysis patients, mostly subclinical hypothyroidism [9]. Raj *et al*. also highlighted a high prevalence of thyroid abnormalities in CKD [10]. These studies reinforce the idea that thyroid dysfunction is a significant issue in pediatric CKD. However, unlike Yadav et al., who reported an increasing trend of hypothyroidism with CKD progression, our study did not find a statistically significant correlation between the two. Mohamed *et al*. also found a significant association between declining eGFR and lower FT3 and FT4 levels [11]. Similarly, Obeed *et al*. found low T3 syndrome as the most common abnormality noted in such groups of children, increasing with CKD progression [12]. This difference might be due to variations in sample sizes, study methods, or population characteristics. Larger, long-term studies are needed to fully understand how CKD severity impacts thyroid function in children. Del Río-Camacho *et al*. explored acquired hypothyroidism in pediatric CKD, supporting our observation that thyroid dysfunction is a frequent comorbidity. However, while we did not find a direct link between CKD severity and thyroid dysfunction, their study suggests that declining kidney function may contribute to thyroid disturbances, emphasizing the need for further research [13]. The mechanisms behind thyroid dysfunction in CKD are complex. Impaired kidney clearance can disrupt thyroid hormone metabolism, while factors like chronic inflammation and malnutrition—common in CKD—may further impact thyroid function [14]. The higher prevalence of hypothyroidism in females mirrors trends seen in the general pediatric population, likely due to hormonal and autoimmune influences. Given the significant burden of thyroid dysfunction in pediatric CKD, routine thyroid screening should be considered, especially for females and those on antihypertensive therapy. Detecting and managing thyroid issues early may lead to better growth outcomes and an improved quality of life for these children. Clinicians should keep thyroid dysfunction on their radar and consider

integrating regular thyroid function testing into CKD care.

Limitations of the Study

The limitations of this study include a relatively small sample size and its cross-sectional nature, which restricts the ability to infer causality. Additionally, potential confounding factors such as nutritional status, duration of CKD, and concurrent medications were not extensively controlled. Future research should aim for larger, multicenter cohorts and longitudinal designs to better understand the dynamics between CKD progression and thyroid function in children.

Conclusion

Thyroid dysfunction is prevalent among pediatric CKD patients, with a higher incidence observed in females. While our study did not find a significant association between CKD severity and thyroid dysfunction, the clinical implications of thyroid abnormalities in this population are substantial. Routine screening and proactive management of thyroid function are recommended to optimize health outcomes in children with CKD.

Conflict of interests

The authors declared no conflict of interest.

Funding source

The authors did not receive any source of funds.

Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

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