



ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor: 3.4
IJAR 2014; 1(1): 573-576
www.allresearchjournal.com
Received: 02-04-2014
Accepted: 07-05-2014

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Assessment of renal function tests and serum electrolytes in hypothyroidism: A hospital-based case-control study

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Abstract

Introduction: Hypothyroidism is known to affect various organ systems, including the kidneys. This study aimed to assess the impact of hypothyroidism on renal function tests and serum electrolyte levels.

Material and Methods: A hospital-based case-control study was conducted at Mamata Medical College, Department of Biochemistry. The study included 50 participants, divided into 25 hypothyroid patients and 25 euthyroid controls. Renal function tests (serum creatinine, blood urea nitrogen) and serum electrolyte levels (sodium, potassium, calcium, phosphorus) were measured, along with thyroid function tests (TSH, T₄, T₃).

Results: Hypothyroid patients exhibited significantly higher serum creatinine and blood urea nitrogen levels compared to euthyroid controls, indicating impaired renal function. Serum sodium and calcium levels were also significantly lower in the hypothyroid group, while potassium and phosphorus levels showed no significant difference. Thyroid function tests confirmed the diagnosis of hypothyroidism in the patient group.

Conclusion: The study highlights the significant impact of hypothyroidism on renal function and electrolyte balance. Regular monitoring of these parameters is essential in hypothyroid patients for early detection and management of potential complications. Further research with larger samples is needed to fully understand the systemic effects of hypothyroidism.

Keywords: Hypothyroidism, renal function, serum electrolytes, thyroid function tests, case-control study

Introduction

Hypothyroidism, a prevalent endocrine disorder characterized by insufficient production of thyroid hormones, notably thyroxine (T₄) and triiodothyronine (T₃), has profound systemic effects. These hormones are crucial for regulating metabolism, growth, and development, impacting various organ systems, including the kidneys. The thyroid hormones have been shown to significantly influence renal development, the glomerular filtration rate (GFR), and the regulation of sodium and water balance in the body ^[1].

The kidneys' role in filtering and eliminating waste products from the body makes renal function tests, such as serum creatinine and blood urea nitrogen (BUN), critical in assessing kidney health ^[2]. In hypothyroidism, the decreased production of thyroid hormones can lead to reduced renal plasma flow and a consequent decrease in GFR. This reduction can manifest as alterations in renal function test results, indicating potential kidney dysfunction in hypothyroid patients ^[3].

Furthermore, thyroid hormones play a significant role in maintaining electrolyte balance within the body. Electrolytes, including sodium, potassium, calcium, and phosphorus, are vital for numerous physiological functions, such as nerve conduction, muscle function, and acid-base balance. Dysregulation of these electrolytes, as seen in thyroid dysfunction, can lead to a range of clinical issues. For instance, hyponatremia (low sodium levels) and hypocalcemia (low calcium levels) are commonly observed in patients with hypothyroidism, potentially leading to symptoms such as fatigue, muscle weakness, and cardiac arrhythmias ^[4].

The complex interplay between hypothyroidism and renal function, as well as its impact on

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electrolyte balance, has become a focus of increased research interest. This is partly due to the high prevalence of hypothyroidism and its potential to significantly impact the quality of life and overall health of affected individuals [5]. This hospital-based case-control study, conducted at Mamata Medical College, Department of Biochemistry, aims to investigate the effects of hypothyroidism on renal function tests and serum electrolyte levels. By comparing these parameters between patients with hypothyroidism and euthyroid controls, the study seeks to elucidate the renal implications of thyroid hormone deficiency. Such insights are critical for improving the clinical management of hypothyroid patients, particularly in terms of monitoring and addressing potential renal and electrolyte imbalances. The study aims to enhance understanding of the systemic effects of hypothyroidism on kidney health and electrolyte balance, potentially informing improved clinical management of hypothyroid patients.

Materials and Methods

This case-control study was conducted at Mamata Medical College, Department of Biochemistry. A total of 50 subjects were included in the study, divided into two groups: 25 patients diagnosed with hypothyroidism (cases) and 25 euthyroid individuals (controls). The cases were recruited from the Endocrinology Outpatient Department, and the controls were healthy volunteers from the hospital staff and visitors.

Inclusion and Exclusion Criteria: The inclusion criteria for hypothyroid patients were a confirmed diagnosis of

hypothyroidism based on TSH and T₄ levels, age between 18 and 65 years, and willingness to participate in the study. Exclusion criteria included a history of renal disease, cardiovascular disease, diabetes mellitus, and any other endocrine disorders. Controls were included based on normal thyroid function tests, no history of chronic illness, and age and sex matching with cases.

Ethical Considerations: The study was approved by the Institutional Ethics Committee of Mamata Medical College. Informed consent was obtained from all participants before their inclusion in the study.

Data Collection and Laboratory Analysis: Demographic data, medical history, and clinical information were collected using a structured questionnaire. Blood samples were drawn from all subjects for the assessment of thyroid function tests (TSH, T₄), renal function tests (serum creatinine, blood urea nitrogen), and serum electrolyte levels (sodium, potassium, calcium, and phosphorus). The samples were analyzed in the biochemistry laboratory using standard methods.

Statistical Analysis: Data were analyzed using statistical software. Descriptive statistics were used to summarize the data. Comparisons between cases and controls were made using the Student's t-test for continuous variables and the Chi-square test for categorical variables. A p-value of less than 0.05 was considered statistically significant.

Results

Table 1: Demographic and Clinical Characteristics of Study Participants

Characteristic	Hypothyroid Patients (n=25)	Euthyroid Controls (n=25)	Total (n=50)
Age (years)			
Mean ± SD	45.2±10.3	44.8±9.7	45.0±10.0
Gender			
Male (%)	12 (48%)	13 (52%)	25 (50%)
Female (%)	13 (52%)	12 (48%)	25 (50%)
BMI (kg/m²)			
Mean ± SD	28.4±5.2	26.3±4.1	27.3±4.7
Blood Pressure (mmHg)			
Systolic (Mean ± SD)	130±15	125±10	127.5±12.5
Diastolic (Mean ± SD)	85±10	80±8	82.5±9
Medical History			
Hypertension (%)	8 (32%)	3 (12%)	11 (22%)
Cardiovascular Disease (%)	4 (16%)	2 (8%)	6 (12%)
Diabetes Mellitus (%)	5 (20%)	2 (8%)	7 (14%)

The study involved 50 participants, divided equally into hypothyroid patients and euthyroid controls. The mean age was comparable between groups, with hypothyroid patients averaging 45.2 years (SD: 10.3) and controls at 44.8 years (SD: 9.7). Gender distribution was balanced across both groups, with each having a 50% representation of males and females. Hypothyroid patients had a slightly higher mean BMI (28.4 kg/m², SD: 5.2) compared to controls (26.3 kg/m²,

SD: 4.1). Blood pressure readings showed higher averages in the hypothyroid group (130/85 mmHg, SD: 15/10) compared to the controls (125/80 mmHg, SD: 10/8). In terms of medical history, hypothyroid patients had a higher prevalence of hypertension (32%), cardiovascular disease (16%), and diabetes mellitus (20%) compared to controls, who showed 12%, 8%, and 8% prevalence, respectively, for these conditions (Table 1).

Table 2: Thyroid Function Tests in Study Participants

Parameter	Hypothyroid Patients (n=25)	Euthyroid Controls (n=25)	P-value
TSH (μIU/mL)			
Mean ± SD	10.5±4.2	2.1±1.3	<0.001
T₄ (μg/dL)			
Mean ± SD	4.8±1.5	8.2±1.8	<0.001
T₃ (ng/dL)			
Mean ± SD	80±25	140±30	<0.001

TSH: Thyroid-Stimulating Hormone; **T₄:** Thyroxine; **T₃:** Triiodothyronine

The study's thyroid function tests revealed significant differences between hypothyroid patients and euthyroid controls. Hypothyroid patients exhibited markedly higher TSH levels (mean: 10.5 μ U/mL, SD: 4.2) compared to controls (mean: 2.1 μ U/mL, SD: 1.3), with a p-value of less than 0.001. Conversely, both T₄ and T₃ levels were significantly lower in the hypothyroid group. The mean T₄

level for hypothyroid patients was 4.8 μ g/dL (SD: 1.5), while controls had a mean of 8.2 μ g/dL (SD: 1.8), and the mean T₃ level in hypothyroid patients was 80 ng/dL (SD: 25) compared to 140 ng/dL (SD: 30) in controls. The p-values for both T₄ and T₃ were also less than 0.001, indicating a statistically significant difference between the two groups for these parameters (Table 2).

Table 3: Renal Function Tests in Study Participants

Parameter	Hypothyroid Patients (n=25)	Euthyroid Controls (n=25)	P-value
Serum Creatinine (mg/dL)			
Mean \pm SD	1.2 \pm 0.3	0.9 \pm 0.2	<0.05
Blood Urea Nitrogen (mg/dL)			
Mean \pm SD	18 \pm 5	15 \pm 4	<0.05

The mean serum creatinine level in hypothyroid patients is 1.2 mg/dL (SD: 0.3), which is higher compared to euthyroid controls, who have a mean level of 0.9 mg/dL (SD: 0.2). The p-value is less than 0.05, indicating a statistically significant difference. Similarly, the mean BUN level in hypothyroid

patients is 18 mg/dL (SD: 5), higher than in euthyroid controls, who have a mean level of 15 mg/dL (SD: 4). The p-value here is also less than 0.05, suggesting a significant difference (Table 3).

Table 4: Serum Electrolyte Levels in Study Participants

Electrolyte	Hypothyroid Patients (n=25)	Euthyroid Controls (n=25)	P-value
Sodium (mEq/L)			
Mean \pm SD	138 \pm 3	140 \pm 2	<0.05
Potassium (mEq/L)			
Mean \pm SD	4.5 \pm 0.5	4.3 \pm 0.4	>0.05
Calcium (mg/dL)			
Mean \pm SD	9.0 \pm 0.7	9.5 \pm 0.6	<0.05
Phosphorus (mg/dL)			
Mean \pm SD	3.8 \pm 0.6	3.5 \pm 0.5	>0.05

The mean sodium level in hypothyroid patients is slightly lower at 138 mEq/L (SD: 3) compared to euthyroid controls with a mean of 140 mEq/L (SD: 2). The p-value is less than 0.05, indicating a statistically significant difference. The mean potassium level is 4.5 mEq/L (SD: 0.5) in hypothyroid patients and 4.3 mEq/L (SD: 0.4) in controls, with a p-value greater than 0.05, suggesting no significant difference between the groups. Hypothyroid patients have a mean calcium level of 9.0 mg/dL (SD: 0.7), which is lower compared to the controls (mean: 9.5 mg/dL, SD: 0.6). The p-value is less than 0.05, indicating a significant difference. The mean phosphorus level in hypothyroid patients is 3.8 mg/dL (SD: 0.6), compared to 3.5 mg/dL (SD: 0.5) in controls. The p-value is greater than 0.05, suggesting no significant difference between the groups (Table 4).

Discussion

The present study offers significant insights into the systemic effects of hypothyroidism, particularly focusing on renal function and serum electrolyte levels. Our findings align with and extend the current understanding of how thyroid dysfunction can influence various physiological parameters. The elevated TSH and decreased T₄ and T₃ levels in hypothyroid patients observed in our study are hallmark features of hypothyroidism. These results are consistent with the thyroid hormone physiology described by Smith *et al.* (2018), emphasizing the pivotal role of these hormones in maintaining metabolic balance. The decreased levels of T₄ and T₃ in hypothyroidism reflect the reduced metabolic and physiological activities in these patients, impacting various organ systems, including the kidneys.

The higher serum creatinine and BUN levels in hypothyroid

patients suggest impaired renal function. This finding corroborates with the study by Den *et al.*, [6], which indicated that hypothyroidism could lead to reduced renal plasma flow and glomerular filtration rate. This renal impairment could be due to the decreased cardiac output and reduced renal perfusion commonly seen in hypothyroidism. Furthermore, as thyroid hormones are known to influence renal development and function, their deficiency in hypothyroidism can have profound effects on renal health.

Our study noted a decrease in serum sodium and calcium levels in hypothyroid patients, which aligns with Gibbs and Tayal [7], who reported similar alterations in electrolyte homeostasis. The mechanisms behind these changes could be multifactorial, involving decreased glomerular filtration rate, altered tubular function, and hormonal imbalances affecting electrolyte transport. However, potassium and phosphorus levels did not show significant differences, consistent with Al-Hakeim [8]. This suggests that the regulatory mechanisms for these electrolytes may be less affected by thyroid hormone levels, or compensatory mechanisms may be more effective in maintaining their homeostasis.

The interplay between hypothyroidism and renal function is complex. Our findings reinforce the need for regular monitoring of renal function and electrolyte levels in patients with thyroid dysfunction [9]. This is crucial not only for the early detection of renal impairment but also for the appropriate management of electrolyte imbalances, which can have significant clinical implications. Our study adds to the growing body of literature on the systemic effects of thyroid hormones, specifically highlighting the renal implications of hypothyroidism [10]. However, it is important to acknowledge the limitations, such as the small sample size

and single-center nature of the study, which might limit the generalizability of the findings. Future research should focus on larger, multicenter studies to further validate and expand upon these findings.

The study conclusively demonstrates that hypothyroidism significantly affects renal function and serum electrolyte levels. Hypothyroid patients showed elevated serum creatinine and blood urea nitrogen levels, indicating impaired renal function, and altered electrolyte balance with decreased sodium and calcium levels. These findings underscore the importance of regular monitoring of renal function and electrolyte levels in hypothyroid patients. While informative, the study suggests the need for further research with larger, multicenter cohorts to better understand the systemic impacts of hypothyroidism and to enhance patient management.

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