

## Assessment of serum minerals and electrolytes in thyroid patients

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### Abstract

**Introduction:** The effect on thyroid hormones on electrolytes and minerals has not been well established and the underlying mechanisms are not well understood. Only few data on the association between thyroid function and electrolyte disorders exists. Thus our aim was to assess the levels of serum electrolytes and minerals in the patients with thyroid disorders.

**Materials and methods:** 75 patients and 30 controls were included. Thyroid hormones (T3, T4, TSH) were measured by vidas autoanalyser. Serum calcium, phosphorous and magnesium were estimated by kit based method using semiautoanalyser. Serum sodium, potassium and chlorides were estimated using ion selective electrodes. Statistical analysis was done using SPSS 16.

**Results:** Patients with subclinical hypothyroidism and overt hypothyroidism showed significant decrease in serum calcium and sodium levels and significant increase in serum phosphorous, magnesium, potassium and chloride levels ( $p < 0.05$ ). In case of subclinical hyperthyroidism significant difference could not be obtained among controls and patients ( $p > 0.05$ ). However for overt hyperthyroid patients, serum phosphorous was significantly decreased and serum sodium was increased significantly ( $p < 0.05$ ). Rest of the results were non significant. When correlated with TSH, serum calcium and sodium showed negative correlation whereas it was positive for serum phosphorous, magnesium, potassium and chloride in case of hypothyroidism. For hyperthyroid patients, correlation was negative for magnesium and chloride whereas positive for the rest parameters. But none of correlations were statistically significant ( $p > 0.05$ ).

**Conclusion:** Thyroid patients should be regularly checked for serum electrolytes. Early detection and treatment can prevent the further complications and will be helpful during the management of thyroid patients.

**Keywords:** Subclinical hypothyroidism (SCH), hypothyroidism, subclinical hyperthyroidism, hyperthyroidism

### 1. Introduction

Electrolytes play an important role in many body processes, such as controlling fluid levels, acid-base balance (pH), nerve conduction, blood clotting and muscle contraction [1]. Thyroid disease is common in the general population, and the prevalence increases with age. In India, 42 million people are suffering from thyroid diseases; hypothyroidism being the commonest thyroid disorder [2]. Thyroid hormone is a central regulator of body haemodynamic, thermoregulation and metabolism. Thyroid hormones perform a wide array of metabolic functions including regulation of lipid, carbohydrate, protein and electrolyte and mineral metabolisms. While the effect of thyroid hormones on lipid metabolism is well

known, the effect on electrolytes and minerals has not been well established and also the underlying mechanisms are not well understood [3].

Sodium and potassium are important components of the enzyme  $\text{Na}^+/\text{K}^+$  ATPase, which is an enzyme present on the cell membrane that helps in the transport of water and nutrients across the cell membrane [4]. Thyroid hormones regulate the activity of sodium potassium pumps in most of the tissues [5]. In recent years research has focused on outcomes of patients with electrolyte disorders, mainly hypo- and hypernatraemia, which were found to be associated with increased mortality [6]. But also disorders of

potassium, phosphate and magnesium are shown to be the predictors for increased mortality [7, 8].

Thyroid hormones are essential for normal growth and maturation of skeletal system. Thyroid dysfunction is frequently associated with disturbances of calcium and phosphorous homeostasis. Thyroid disorders are important cause of secondary osteoporosis [9]. Few studies show normal serum calcium and phosphorous levels [10] while others show decreased levels in hypothyroidism [11]. Even though the changes in the calcium and magnesium may be slight in thyroid disorders, these disturbances will be important for patient in the long run [12]. In hypothyroidism there is a depressed turnover due to impaired mobilization of calcium into the bone than leads to decrease the blood calcium level. In hyperthyroidism there is poor mobilization of calcium than leads to increases the blood calcium level. In hypothyroidism increased production of thyroid calcitonin can promote the tubular reabsorption of phosphate and also favors the tubular excretion of calcium [13]. In hyperthyroidism decreased production of thyroid calcitonin [10]. Can promote the tubular excretion of phosphate and also favors the tubular absorption of calcium [13].

In many literatures different electrolyte disorders are associated with thyroid dysfunction. In severe hypothyroidism and myxoedema hyponatraemia is described to be a consequence of enhanced renal water retention mediated by vasopressin. On the other hand, hypokalaemia,

hypomagnesaemia and hypercalcaemia were mentioned in patients with thyrotoxicosis [14]. Thus the present study was undertaken to assess the alterations in the levels of serum electrolytes in hyperthyroid, hypothyroid & euthyroid patients.

## 2. Materials and methods

The study was conducted in FH medical college and Hospital. Total of 75 patients and 30 controls were included. The patients were divided into three groups depending on thyroid hormone levels as euthyroid (controls), hyperthyroid & hypothyroid respectively. Patients with history of intake of thyroid drugs, hypertensive, diabetes mellitus and obesity were excluded from the study. Thyroid hormones were estimated by using Vidas autoanalyser. Electrolyte levels (Na<sup>+</sup>, K<sup>+</sup> & Cl<sup>-</sup>) were measured by ion selective electrode. Serum calcium by Arsenazo III method, phosphorous by ammonium molybdate method and magnesium by kit method on semiautoanalyser.

## 3. Results

**Table 1: Distribution of study groups**

Subjects	Percentage
Euthyroid	30 (100%)
Subclinical hypothyroidism	15 (20%)
Hypothyroidism	35 (46.7%)
Subclinical hyperthyroidism	7 (9.3%)
Hyperthyroidism	18 (24%)

**Table 2: Comparison of analytes between control and subclinical hypothyroidism patients (mean±sd)**

Tests	Control	Patients (SCH)	p value
T3 (tri-iodothyronine)	2.27±0.63	1.85±0.64	<0.05*
T4(thyrxine)	96.92±11.13	85.99±13.09	<0.01**
TSH (thyroid stimulating hormone)	2.63±1.14	17.85±11.52	<0.001***
Ca (calcium)	9.2±0.49	7.53±0.36	<0.001***
P (phosphorous)	3.5±0.44	3.88±0.36	<0.01**
Mg (magnesium)	1.55±0.29	2.15±0.25	<0.001***
Na (sodium)	138.16±1.89	127.2±3.63	<0.001***
K (potassium)	3.92±0.42	4.18±0.31	<0.05*
Cl( chloride)	100.73±3.82	104.86±4.25	<0.01**

(\* indicates statistically significant result)

**Table 3: Comparison of analytes between control and hypothyroidism patients (mean±sd)**

Tests	Control	Patients (hy)	p value
T3 (tri-iodothyronine)	2.27±0.63	0.41±0.311	<0.001***
T4(thyrxine)	96.92±11.13	41.68±16.74	<0.001***
TSH (thyroid stimulating hormone)	2.63±1.14	32.18±19.24	<0.001***
Ca (calcium)	9.2±0.49	6.78±0.82	<0.001***
P (phosphorous)	3.5±0.44	4.23±0.52	<0.001***
Mg (magnesium)	1.55±0.29	2.28±0.27	<0.001***
Na (sodium)	138.16±1.89	125.14±5.47	<0.001***
K (potassium)	3.92±0.42	4.67±0.74	<0.001***
Cl( chloride)	100.73±3.82	103.25±4.85	<0.05*

(\* indicates statistically significant result)

**Table 4: Comparison of analytes between control and subclinical hyperthyroidism patients (mean±sd)**

Tests	Control	Patients (SCH)	p value
T3 (tri-iodothyronine)	2.27±0.63	4.15±2	<0.05*
T4(thyrxine)	96.92±11.13	114.17±24.14	>0.05
TSH (thyroid stimulating hormone)	2.63±1.14	0.06±0.03	<0.001***
Ca (calcium)	9.2±0.49	8.78±0.47	>0.05
P (phosphorous)	3.5±0.44	3.72±0.29	>0.05
Mg (magnesium)	1.55±0.29	1.67±0.16	>0.05
Na (sodium)	138.16±1.89	143.42±11.47	>0.05
K (potassium)	3.92±0.42	4.04±0.55	>0.05
Cl ( chloride)	100.73±3.82	101.87±3.62	>0.05

(\* indicates statistically significant result)

**Table 5: Comparison of analytes between control and hyperthyroidism patients (mean±sd)**

Tests	Control	Patients (SCH)	p value
T3 (tri-iodothyronine)	2.27±0.63	6.97±2.21	<0.001***
T4(thyrxine)	96.92±11.13	181.34±47.38	<0.001***
TSH (thyroid stimulating hormone)	2.63±1.14	0.06±0.04	<0.001***
Ca (calcium)	9.2±0.49	9.1±0.42	>0.05
P (phosphorous)	3.5±0.44	2.88±0.43	<0.001***
Mg (magnesium)	1.55±0.29	1.68±0.22	>0.05
Na (sodium)	138.16±1.89	143.33±7.85	<0.01**
K (potassium)	3.92±0.42	3.95±0.38	>0.05
Cl ( chloride)	100.73±3.82	100.33±3.51	>0.05

(\* indicates statistically significant result)

**Table 6: Pearson's correlation coefficient (r) between various parameters and TSH**

TSH	Correlation coefficient (hypothyroidism)	Correlation coefficient (hyperthyroidism)
Calcium	-0.453	0.076
Phosphorous	0.399	0.091
Magnesium	0.119	-0.058
Sodium	-0.127	0.268
Potassium	0.044	0.081
Chloride	0.293	-0.001

#### 4. Discussion

In this study 46.7% of the patients were suffering from hypothyroidism whereas 9.3% had subclinical hyperthyroidism. Hypothyroidism is one of the most prevalent endocrine diseases. It can lead to a variety of clinical situations, including congestive heart failure, electrolyte disturbances and coma. Hyponatremia is the most common electrolyte abnormality encountered in clinical practice [15]. Thyroid hormone is a central regulator of body haemodynamics, thermoregulation and metabolism. Therefore, it has an influence on renal haemodynamics, glomerular filtration and electrolyte handling [16].

In our study there was significant decrease in serum calcium levels in SCH and hypothyroidism groups ( $p < 0.001$ ) but significant difference could not be obtained in case of subclinical hyperthyroidism and hyperthyroidism ( $p > 0.05$ ). Shivallela *et al* demonstrated a significant decrease in serum calcium of SCH group than control. This is mainly due to the

low levels of Parathyroid hormone and low levels of calcitonin in hypothyroidism [11]. Roopa and Soans reported that thyroxine normally regulates blood calcium level by releasing calcium from cells, by decreasing thyroxine level in blood, less T4 enters the cells and less calcium is released [4]. Animal study done by Kumar and Prasad concludes that renal calcium excretion was increased in rats with high TSH levels [17].

Our study also revealed significantly high phosphorous levels in patients with SCH and hypothyroidism ( $p < 0.01$ ) but the level was significantly low level in case of hyperthyroidism ( $p < 0.001$ ) whereas no such results was obtained for subclinical hyperthyroidism ( $p > 0.05$ ). Our finding was in accordance with Elhashimi *et al* [18]. This also agrees with a study done by Suneel *et al*, who reported that there was a significant decrease of the mean phosphate in patients with hypothyroidism compared to control. This is mainly due to calcitonin which regulates the over tubular reabsorption of phosphate

from kidney. Phosphate levels are raised due to compensatory effect of calcitonin and parathormone which favour tubular excretion (by inhibiting tubular reabsorption) [19].

Patients with SCH and hypothyroidism showed significantly high levels of serum magnesium levels as compared to normal controls ( $p < 0.001$ ) whereas those with subclinical hyperthyroidism and hyperthyroidism did not show any significant difference ( $p > 0.05$ ). Our result was supported by Jaskin K [20], Schwarza [14] and Frizel [21]. Frizel in his study states that both plasma magnesium and ionized magnesium were increased in hypothyroidism [21]. Murgud *et al* exhibited significantly elevated levels of serum magnesium compared to the controls ( $p < 0.001$ ) [4].

In our study the serum sodium levels in SCH and hypothyroidism were markedly decreased as compared to healthy controls ( $p < 0.001$ ) whereas serum potassium and chloride levels were found to be significantly increased in both subclinical hypothyroid and hypothyroid patients when compared to controls ( $p < 0.05$ ). In the subclinical hyperthyroid patients there was no significant difference in the levels of serum sodium, potassium and chloride when compared with normal controls ( $p > 0.05$ ). However statistically significant difference was seen in the level of sodium ( $p < 0.05$ ) but not in the levels of potassium and chloride ( $p > 0.05$ ) in case of hyperthyroid patients.

Sodium and potassium are important components of the enzyme Na-K ATPase, which is an enzyme on the cell membrane that helps in the transport of water and nutrients across the cell membrane. Thyroid hormones regulate the activity of sodium potassium pumps in most of the tissues. In hypothyroidism, because of low potassium levels, and because of deficiency of thyroid hormones, this enzyme is affected, resulting in accumulation of water inside the cells and causing edema. This is said to be one of the mechanisms responsible for weight gain seen in hypothyroid patients [4].

We also correlated the levels of serum calcium, phosphorous, magnesium, sodium, potassium and chloride with the TSH. In case of hypothyroidism, serum calcium and sodium were negatively correlated with TSH but serum phosphorous, magnesium, potassium and chloride were positively correlated. Whereas in case of hyperthyroidism, correlation between serum magnesium and chloride was negative and rest were positive. None of the correlations were statistically significant ( $p > 0.05$ ). Morgood *et al* showed significant negative correlation between TSH, serum sodium, potassium and calcium in hypothyroidism whereas phosphorous and magnesium showed significant positive correlation [4]. Elhasmi e

Hassan *et al* and Christoph *et al* [14] also found a significant correlation of serum calcium and phosphate with TSH, T3 and T4 [18]. Gammage reported negative correlation of serum phosphorous with TSH. The study of Kavitha *et al* showed significant positive correlation ( $p < 0.003$ ) with TSH in overt hypothyroidism [22].

## 5. Conclusion

This study concludes that serum calcium and sodium levels were decreased whereas serum phosphorous, magnesium, potassium and chloride levels were increased in subclinical hypothyroidism and overt hypothyroidism compared to euthyroids. But in case of subclinical hyperthyroidism there was no significant difference in the levels of the measured electrolytes among the controls and patients. However significant increase in levels of sodium and significant decrease in levels of phosphorous could be obtained in case of overt hyperthyroidism. This suggests that hypothyroid and hyperthyroid patients should be regularly checked for serum electrolytes. Early detection and treatment can prevent the further complications related to the disorder and will be helpful during the management of thyroid patients.

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