

Study of Electrolyte status in patients with Thyroid dysfunction attending a tertiary care hospital of North Bengal

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Abstract

Context: Thyroid disorders have widespread systemic manifestations including their effects on body mineral homeostasis in many different ways. Thyroid hormones control urinary excretion of minerals like Magnesium, zinc, sodium, potassium etc and minerals like Zn helps in peripheral conversion of inactive T4 to its active T3 form. Electrolyte abnormality is a common finding in the patients with thyroid dysfunction which can effect the disease morbidity.

Aims & Objective: The present study was carried out to access the importance of Electrolyte status in the study subjects and to use the information for lowering the mortality and morbidity associated with the disease process.

Materials & Methods: The study population was divided into normal control group consisting of 40 healthy individuals and a test group consisting of 80 patients out of whom 40 were diagnosed to be having primary hypothyroidism and 40 to be having primary hyperthyroidism. Electrolyte status was assessed by serum calcium, serum phosphorus, serum magnesium, serum zinc, serum sodium and serum potassium

Results: There is a significant increase in levels of serum calcium and phosphorus in group-II (P<0.001) and significant decrease in their levels in group-I (P<0.001) compared to control. Serum Magnesium showed a significant decrease in test groups-II (P<0.001) and increase in test group-I (P<0.001) compared to controls. Serum sodium showed significant decrease in test group-I (P<0.001) and test group-II (P=0.007) but the study did not show any significant difference in level of serum zinc and potassium in test group-I and II when compared to controls.

Conclusion: Thyroid dysfunction results in an array of electrolyte abnormalities which increases the morbidity and mortality of the disease process. By proper maintenance of the electrolytes within normal limit, we can employ preventive strategies for better management of the patients and thereby improve their survival.

Keywords: Hypothyroidism, Hyperthyroidism, Free T4, TSH, Hypocalcemia, Hypercalcemia.

1. Introduction

Thyroid hormones tri-iodothyronine (T₃) and thyroxin (T₄) play critical roles in cellular development and differentiation, help to maintain thermogenic, mineral and metabolic homeostasis in the body. Overt abnormalities in thyroid function are common endocrine disorders affecting 5-10% of individuals over a lifespan and even the persons living in non goitrogenic regions are no exception. As a result thyroid dysfunction frequently involves many organ systems producing diverse specific as well as non-specific signs and symptoms.

Bone mineral metabolism gets disturbed in thyroid dysfunction and frequently seen in hyperthyroidism. Thyroid hormones have well documented effects on

osteoblasts via nuclear receptors to stimulate osteoclastic bone resorption. Thyroxin normally regulates blood calcium level by releasing calcium from cells, by decreasing thyroxin level in blood, less T4 enters the cells and less calcium is released [1]. Also, hypercalcemia was described in patients with hyperthyroidism due to an enhanced bone turn over [2]. Thyroid hormones regulate phosphorus metabolism. Schwarz *et al* who reported significant positive correlation between phosphorus and TSH level [3]. Hyperthyroidism is thus one of the most major causes of secondary osteopenia and osteoporosis. Opposite effects are seen in hypothyroidism.

Hypocalcemia may cause neuromuscular irritability including perioral paraesthesia, tingling of toes & fingers, spontaneous or latent tetany[4]. Sometimes hypercalcemia may be severe enough to induce anorexia, polyuria and occasionally impairment of renal function [5]. Although the changes in serum calcium & phosphorous levels may be slight in thyroid disorders and may not be an acute problem for the patient, it is possible that these disturbances will be important for patient in the long term.

Plasma magnesium concentration appears to be consistently elevated in thyroid deficiency, possibly due to renal retention [6]. Serum magnesium levels on the other hand are decreased in hyperthyroidism and urinary excretion of magnesium is increased in these patients. The data are interpreted as thyroid hormone having a direct effect on tubular calcium and magnesium reabsorption in addition to its numerous effects on blood flow, glomerular filtration rate and tubular sodium transport.

Plasma magnesium tends to be elevated in hypothyroidism presumably as a result of renal retention which has been thought to be the result of hypofiltration[7]. In contrast to calcium, magnesium is reabsorbed to a much less extent in the proximal and distal tubule compared to the loop of Henle (thick ascending limb) which plays a pivotal role in renal magnesium reabsorption and magnesium homeostasis. Thyroid deficiency leads to a marked renal conservation of magnesium. We have shown that magnesium reabsorption within Henle's loop is regulated in a major way by the absolute concentration of plasma calcium and/or plasma magnesium [8]. Hypocalcemia would be expected to increase both calcium and magnesium reabsorption.

In hypothyroidism diminished ability of the kidneys to excrete free water fails to produce maximum water dilution, leading to water retention with consequent hyponatremia. Skowsky and Kikuchi showed that plasma ADH was elevated and was not sufficiently suppressed in response to decreases in plasma osmolality in hypothyroidism [9]. Hypothyroidism [10] decreases in cardiac output and increases in peripheral resistance have been shown in hypothyroidism, which give rise to hypovolemia leading to increased ADH release [11]. Taken together, it is assumed that the oversecretion of ADH and renal hypo function in hypothyroidism cause a fall in free water formation, thereby resulting in hyponatremia. On the other hand hypokalemia was mentioned in patients with hyperthyroidism. The most accepted explanation is that the thyroid hormone increases activity of the Na⁺-K⁺ ATPase pump, resulting in increased cellular uptake of potassium [12].

So, Electrolyte abnormality is a common finding in the patients with thyroid dysfunction which can effect the

disease morbidity. Identification of those abnormalities can help in reducing various morbidities associated with thyroid dysfunction.

2. Materials and Method

The present study was conducted in the Department of Biochemistry, North Bengal Medical College and Hospital, Sushrutanagar, Darjeeling. Oral informed consent was obtained from the patients and normal subjects prior to study. Control group consisting of 40 individuals were selected randomly among persons from different sectors of the society belonging to diverse socio economic status and were not having pathology referable to any system either in the past or present. In the present study, 40 cases each of Primary Hypothyroidism (group I) and Primary Hyperthyroidism (group II) were selected on the basis of clinical history, clinical examination and relevant laboratory parameters who came in the Department of Biochemistry, NBMC, Darjeeling for thyroid profile estimation. Patients with Hypertension, Diabetes mellitus, Liver disease, Renal Disease, Alcoholism, or other major medical conditions or those who were on mineral supplementation, anti thyroid drugs or any medications that might affect the measured mineral concentrations, Anaemia, proteinuria and Hematuria are excluded from the study. Taking all aseptic and antiseptic precautions, 3ml of blood is drawn from the Ante cubital vein of the patient. Serum calcium was measured by OCPC method [13], serum phosphorus by Molybdate U.V method [14], serum magnesium by Calmagite method [15], serum zinc by Photometric method [16] using autoanalyzer EM-360 and standard kits for the respective parameters. Serum sodium and potassium were measured by Electrolyte analyzer based on ISE principle [17]. The thyroid profile is estimated using ELISA method [18].

3. Results and Observation

The test group comprises of 80 patients; grouped into 2 subcategories of 40 patients each in Group I (patients with primary hypothyroidism) and Group II (patients with primary hyperthyroidism). Our results from table I list the mean values of various biochemical parameters in Control and patients with thyroid dysfunction- Group I and II. Serum calcium, serum phosphorus showed significant increase in group-II and decrease in group-I. Serum Magnesium showed significant increase in Group-I and decrease in Group-II. Serum sodium showed significant decrease in both the groups but more in Group-I compared to control but the study did not show any significant difference in level of serum Zinc and potassium in test group-I and II when compared with control.

Table 1: Mean and standard deviation of Calcium, phosphorus, Magnesium, Zinc, sodium and Potassium in the three groups

Parameters	Mean ± SD		
	Normal Control	Test Group - I	Test Group- II
Serum Calcium (mg/dl)	9.515±0.477	8.30±0.41	11.54±0.669
Serum Phosphorus (mg/dl)	3.73±0.46	2.24±0.202	5.08±0.12
Serum Magnesium(mEq/L)	1.99± 0.259	2.59 ±0.123	1.307±0.186
Serum Zinc (µg/dl)	86.95±13.31	85.75±14.36	85.8±13.22
Serum Sodium (mmol/L)	138.75±5.13	131.35±5.19	134.65±5.39
Serum Potassium (mmol/L)	4.25±0.511	4.28±0.538	4.29±0.512

Table 2: Comparisons of means between groups

Parameters	Control v/s Test Group I			Control v/s Test Group II			Test Group-1 v/s Test Group II		
	Df	't'	P value	Df	't'	P value	Df	't'	P value
Serum Calcium	78	12.04	<0.001*	78	-15.60	<0.001*	78	-25.92	<0.001*
Serum Phosphorus	78	8.54	<0.001*	78	-17.83	<0.001*	78	-76.30	<0.001*
Serum Magnesium	78	-13.18	<0.001*	78	13.506	<0.001*	78	36.33	<0.001*
Serum Zinc	78	0.388	0.69 (NS)	78	0.388	0.699 (NS)	78	-0.016	0.987 (NS)
Serum Sodium	78	6.41	<0.001*	78	3.481	0.001*	78	-2.786	0.007 *
Serum Potassium	78	-0.255	0.79 (NS)	78	-0.393	0.696 (NS)	78	-0.128	0.899 (NS)

(*: Highly Significant, NS: No significance)

4. Discussion

The present study shows that patients in the test group with primary hyperthyroidism had significantly higher values of serum calcium as compared to the control subjects ($P<0.001$) whereas the test group with primary hypothyroidism had lower values of serum calcium as compared to controls ($P<0.001$). The control group comprising of 40 individuals had a mean serum calcium level of 9.515 ± 0.477 mg/dl, ranging from 8.7-10.5 mg/dl and a median value of 9.40 mg/dl. The test group, which was further divided into 2 sub-categories Group I and Group II had a mean serum Calcium value 8.30 ± 0.41 and 11.54 ± 0.669 mg/dl and a median value of 8.2 mg/dl and 11.650 mg/dl respectively.

The study also shows that patients in the test group with primary hyperthyroidism had significantly higher values of serum phosphorus as compared to the control subjects ($P<0.001$) whereas the test group with primary hypothyroidism had lower values of serum phosphorus as compared to controls ($P<0.001$). The control group comprising of 40 individuals had a mean serum phosphorus level of 3.73 ± 0.46 mg/dl, ranging from 2.9-4.5 mg/dl and a median value of 3.5 mg/dl. The test group, which was further divided into 2 sub-categories Group I and Group II had a mean serum phosphorus value of 2.24 ± 0.202 mg/dl and 5.08 ± 0.12 mg/dl and a median value of 2.21 mg/dl and 5.1 mg/dl respectively..

This finding is comparable to the findings of Shivaleela *et al*, Swaminathan *et al* and Manicort *et al* [19-21]. Elevated serums Calcium and phosphorus levels in the patients with hyperthyroidism confirm that there is an accelerated bone turnover, which is caused from direct stimulation of bone cells by high thyroid hormone concentrations. Thyroid hormones stimulate bone resorption directly there by increasing the serum calcium

and phosphorous levels and suppressing PTH [22]. Opposite effects are seen in Hypothyroidism.

This study shows that patients in the test group with primary hyperthyroidism had significantly lower values of serum magnesium as compared to the control subjects ($P<0.001$) whereas the test group with primary hypothyroidism had higher values of serum magnesium as compared to controls ($P<0.001$). The control group comprising of 40 individuals had a mean serum magnesium level of 1.99 ± 0.259 mEq/L, ranging from 1.5-2.4 mEq/L and a median value of 2.1 mEq/L. The test group, which was further divided into 2 sub-categories Group I and Group II had a mean serum Magnesium value of 2.59 ± 0.123 mEq/L and 1.307 ± 0.186 mEq/L and a median value of 2.6 mEq/L and 1.3 mEq/L respectively. This findings are at par with findings of Jones *et al* and Quamme *et al* [23,24]. Elevation of serum magnesium in hypothyroidism is presumably due to renal retention as a result of hypofiltration. Also hypocalcemia associated with hypothyroidism will result in increase reabsorption of magnesium from the renal tubules.

The study shows that patients in the test group with primary hypothyroidism and hyperthyroidism had significantly lower values of serum sodium as compared to the control subjects ($P<0.001$). The control group comprising of 40 individuals had a mean serum sodium level of 138.75 ± 5.13 mmol/l, ranging from 126-147mmol/l and a median value of 139.50 mmol/l. The test group, which was further divided into 2 sub-categories Group I and Group II had a mean serum sodium value of 131.35 ± 5.19 mmol/l and 134.65 ± 5.39 mmol/l and a median value of 131mmol/l and 135.5mmol/l respectively. This findings are comparable with that of Schwarz *et al* and Adroque *et al* [25,26]. Over secretion of ADH and renal hypo function in hypothyroidism cause a fall in free water formation, thereby resulting in hyponatremia.

Comparison of serum potassium and Zinc levels between the Controls and the different categories of Test subjects does not reveal any statistical significance.

5. Conclusion

Thyroid dysfunction results in number of electrolyte abnormalities which increases the morbidity and mortality of the disease process.

As an outcome within the scope and limitation of the present study that is the number of available patients within the time frame, and the fact that the study was conducted only in one center, it may be proposed that the knowledge of the various risk factors associated with the morbidity and mortality in the patients with thyroid dysfunction can help us to employ preventive strategies for better management of the patients and thereby improving their survival.

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