Effects of Thyroid Dysfunction on Electrolyte Balance of individuals Visiting Outpatient Department of Tertiary Care Institutes

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Abstract

The effect of thyroid hormones on electrolyte balance has not been reported clearly in literature. This study aimed to assess the consequences of thyroid dysfunction on serum electrolyte levels of individuals visiting outpatient department of tertiary care institutes. A total of 88 individuals were included in the study that were distributed into 5 groups: 1) NTF; the individuals visiting outpatient department (OPD) with normal thyroid function, 2) Hypo-TF; the individuals visiting OPD with hypothyroid function, 3) Hyper-TF; the individuals visiting OPD with hyperthyroid function, 4) NTFT; the individuals visiting OPD with normal thyroid function after treatment, and 5) HC; the healthy control individuals with normal thyroid function who did not visited OPD. The blood samples of the individuals of each group were taken and the sera were analysed for thyroid hormones including triiodothyronine (T_3), tetraiodothyronine (T_4), and thyroid-stimulating hormone (TSH) and electrolyte levels.

A statistically significant variation ($P<0.05$) was observed in thyroid hormone levels of different study groups of both genders. The Hyper-TF group showed comparatively higher levels of T_3 and T_4 while TSH level was higher in Hypo-TF group of both male and female individuals. However, no significant variation in electrolyte levels of different study groups was observed. Statistically no siginificant age-dependent variation in thyroid hormones and electrolyte levels of the study groups was noted. The treatment period also showed no siginificant changes in thyroid hormones and sodium ion level. The level of sodium ions was positively correlated with T_3 and T_4 level of control and Hypo-TF groups and TSH of Hyper-TF group. The potassium ion level was negatively correlated with thyroid hormones level of each group except TSH of Hyper-TF group.

Keywords: Thyroid dysfunction, Electrolyte balance, Hypothyroidism, Hyperthyroidism, Thyroid-stimulating hormone, Triiodothyronine, Thyroxine

Introduction

Thyroid hormones including Thyroxin (T3) and Triiodo-thyronine (T4) are secreted in human body from thyroid glands. These are tyrosine-based hormones that stimulate the protein synthesis at transcriptional level (Klein and Ojamaa 2001, Wrutniak-Cabello, Casas et al. 2001, Satyanarayana and Chakrapani 2006). Thyroid hormones also facilitate the growth by improving the nitrogen balance and stimulate the lipid metabolism (Smith, Evans et al. 2002, Unnikrishnan and Menon 2011). They act on the central nervous system (CNS) and are essential for the normal growth of the brain(Bernal and Nunez 1995). Thyroid hormones also control the growth of the lungs and enhance the velocity of respiration (Fisher 1996). These are also involved in the development of bone and maturation of skeletal muscles (Mosekilde, Eriksen et al.

1990).

The abnormalities which are associated to thyroid functions are Goiter (Irregular rise in the size of the thyroid gland), Hyperthyroidism (The increased production of thyroid hormones level (T_3, T_4) by the thyroid gland) and Hypothyroidism (The underproduction of thyroid hormones level (T_3,T_4) by the thyroid gland) (Gaitan, Nelson et al. 1991, Roti and Uberti 2001, Braverman 2002, Cappola and Ladenson 2003). Abnormally increased T3 and T4 levels and decreased levels of TSH lead to Graves' disease (Brent 2008).

Since iodine is vital for the biosynthesis of thyroid hormones. Iodine deficiency is the most frequent cause of hypothyroidism (Zimmermann and Boelaert 2015). The incidence of thyroid dysfunction may disturb diabetes control. Hyperthyroidism is usuallyrelatedtofalling glycemic control and increased requirement of insulin. There is rapid gastrointestinal (GI) absorption of glucose and perhaps increased resistance to insulin (Wu 1999). As Thyroid hormones increase the heart rate or cardiac output, any alteration in the concentration of T3 and T4 may lead to heart failure (Klein and Ojamaa 2001).

Previous studies showed that Serum sodium ion level association was considerably lower in hypothyroid patients (Hanna and Scanlon 1997, Schwarz, Leichtle et al. 2012, Bharti, Shrestha et al. 2015). It has also been reported that serum sodium and potassium ion level were low in hypothyroid patients (Murgod and Soans 2012). While, it was also reported that there is no relationship among low serum sodium ion and high TSH level (Croal, Blake et al. 1997).

However, no studies have been reported on the prevalence and consequencing of thyroid abnormalities in individuals visiting the outpatient department of Tertiary Care Institutes of Pakistan. This research work aimed to study the effect of thyroid dysfunction on electrolyte balance of individuals visiting the Outpatient Department of Multan Institute of Nuclear Medicine and Radiotherapy, Multan, Pakistan. The study also reports the age and duration of treatment-dependent relationships of thyroid dysfunction and electrolyte balance.

Materials and Methods

Study Design

Overall 88 participants were included in the study that were distributed in two major groups: a healthy control group consisting of 16 healthy individuals without any signs or complaint of thyroid dysfunction and thyroid dysfunction (TDF) group consisting of 72 individuals who approached the outpatient department (OPD) of Multan Institute of Nuclear Medicine and radiotherapy (MINAR) Multan with a complaint of some thyroid problem.The TDF group was subdivided into four groups based onthyroid function: 1) An NTF group consisting of 21 outdoor patients with normal thyroid function, 2) Hypo-TF consisting of 15 outdoor patients with hypothyroid function, 3) Hyper-TF consisting of 15 outdoor patients with hyperthyroid function, and 4) NTFT group consisting of 21 outdoor patients recovered to normal thyroid function after treatment. The study was approved by the Advanced Studies and Research Board and Institutional Ethical Committee of Bahauddin Zakariya University, Multan. The participants were informed about the purpose of the research project, written consent was taken and a questionnaire based on the patient'shistory was filled by each participant. The individuals with a history of renal, hepatic or cardiovascular abnormalities were excluded from the study. The blood samples were collected from the participants, the blood plasma and the sera were analyzed for thyroid function and electrolyte balance respectively. The data were statistically analyzed by one-way analysis of variance to find out the variation in the level of thyroid hormones and electrolytes. The flowsheet of the overall research work is given in the scheme of study (Figure 1).

Sample Collection and Processing

The blood sample (5 mL) was collected from each participant in EDTA containing plasma tubes and heparin containing serum tubes and centrifuged at 3000 rpm for 20 min to obtain plasma and serum respectively.The plasma was subjected to analysis of thyroid hormones and the sera were analyzed for electrolyte level immediately after centrifugation.

Analysis of Thyroid hormones level

Thyroid hormone level was determined by chemiluminescent immunoassay based on the Ag-Ab complex (Zhao, Sun et al. 2009). Thyroid hormone level was determined by using the standard kit, Roche, USA.

Analysis of Serum Electrolytes

Serum electrolytes (Na^+, K^+) level was estimated by Ion-Selective Electrode technique (ISE)(Pungor 1998).

Statistical analysis

The results were presented as mean± S.D. The statistical software (SPSS version 24) One-way analysis of variance (ANOVA) was used.

Results

In my research work, we planned to assess the effect of thyroid dysfunction on electrolyte balance. There is a only few literature on the relationship among thyroid dysfunction and electrolyte balance exist. Serum sodium ion level was significantly worse in hypothyroid patients(Schwarz, Leichtle et al. 2012).

The findings of T_3, T_4, and TSH in various study groups (healthy control and thyroid dysfuntion group) are shown in Table I. The level of T_3 in the healthy control and thyroid dysfuntion groups range from 0.59±0.26-5.23±1.81 (nmol/L). The maximum level of T_3 was noticed in hyperthyroid outdoor patients and the minimum level of T_3 was noticed in hypothyroid outdoor patient. The level of T_4 in healthy control and thyroid dysfuntion groups range from 40.60±8.44-236.60±51.0 (nmol/L). The maximum T_4 level was noted in hyperthyroid outdoor patients and the minimum T_4 level was noted in hypothyroid outdoor patients. The level of TSH in healthy control individulas and thyroid dysfuntion groups range from 0.05±0.023-47.10±10.8 (μIU/ml). The maximum TSH level was noted in hypothyroid outdoor patients and the minimum TSH level was noted in hyperthyroid outdoor patients. Statistical significant variation $P<0.05$ was noted in thyroid hormones levels between the healthy control individuals and thyroid dysfuntion groups. The serum sodium ion level in the healthy control and thyroid dysfuntion groups range from 126.7±7.90-141.4±2.79 (mmol/L). The maximum serum sodium ion level was noted in normal individuals and the minimum serum sodium ion level was noted in hypothyroid outdoor pateints. The serum potassium ion level in the healthy control individuals and thyroid dysfuntion groups range from 4.11±0.18-5.86±0.66 (mmol/L). The maximum serum potassium ion level was noted in hyperthyroid outdoor patients and the minimum serum potassium ion level in hypothyroid patients. Statistical difference $p<0.05$ was noted in serum sodium and potassium ions between the healthy control and thyroid dysfuntion groups. The level of T_3, T_4,TSH at different stage of life between the various thyroid dysfuntion and healthy control groups manifest that T_3 level is rised in hyperthyroid outdoor patients having age group 55 to 65 years and the decline level was observed in hypothyroid outdoor patients with age group 35to 45 years and there was a significant difference $p=0.000$. The maximum level of T_4 was noted in hyperthyroid outdoor patients having age group 15 to 25 years and the minimum level of T_4 was noted in hypothyroid outdoor patients having age group 15 to 25 years. The TSH level of different age groups between various thyroid dysfuntion and healthy control groups reveal that TSH level is rised in hypothyroid outdoor patients having age group 55 to 65 years. In the case of serum electrolytes, the sodium and potassium ion level of different age class between various thyroid dysfunction and healthy control groups indicate that sodium ion level is lowered in hypothyroid outdoor patients having age 25 to 35 years. Potassium ion level is rised in hyperthyroid outdoor patients having age 35 to 45 years (Figure 3).

T_3, T_4, and TSH and serum electrolytes level of different durations of treatment in hyperthyroid outdoor patients manifest that the increased level of T_3 was noted in 10 to 15 years and the decreased level was noted in patients having 0 to 5 treatment year. The increased level of T4 was noted in 0 to 5 years and the decreased level was noted in patients having 15 to 20 years of treatment. The increased level of TSH was noted in 15 to 20 years and the decreased level was noted in patients having 5 to 10 treatment period. The maximum level of serum sodium ion level was noted in 15 to 20 treatment period and the minimum level was noted in 5 to 10 treatment period. The increased level of serum potassium ion level was noted in 10 to

15 treatment period and the decreased level was noted in patients having 0 to 5 treatment period (Figure 4).

Discussion

In this research work, we planned to assess the relationship among thyroid hormones and electrolyte imbalance. T_3, T_4, TSH and serum electrolytes levels in male groups presented that T_3 and T_4 levels were rised in hyperthyroid outdoor patients and TSH level was rised in hypothyroid outdoor patients. The serum sodium ion level was lowered in hypothyroid outdoor patients and serum potassium ion level was maximum in hyperthyroid outdoor patients. In female individuals, minimum level of thyroid hormones (T_3 and T_4) was noted in hypothyroid outdoor patients and maximum level of TSH was also noted in hypothyroid outdoor patients. In case of the serum electrolytes levels, both sodium and potassium ion level were lowered in hypothyroid outdoor patients and higher in hyperthyroid outdoor patients (Figure 2). In the female individuals, hypothyroidism disease is ten folds more frequent than males, and its prevalence rises with age (Vanderpump 2011). In my work, it is presented that thyroid dysfunction is more widespread in females as compared to males. Prior data also have showed that hypothyroidism is six fold more frequent in females in contrast to males groups. One of the most predominant endocrine disease is Hypothyroidism. It can cause a range of clinical complications. My research work is parallel with studies of Schwarz and Bharti presented that there was a significant diminish of sodium levels in serum in the patients having high TSH levels in comparison to healthy individuals(Schwarz, Leichtle et al. 2012, Bharti, Shrestha et al. 2015). In Previous studies hyponatremia (low sodium ion level) was more widespread in patients having hypothyroidism in comparison to normal TSH levels. The vital mechinary of the Na^+-K^+ATPase enzyme are sodium and potassium. This enzyme is located on the exterior of the cell membrane that supports the water movement and vital nutrients across the membrane of cell. In the majority tissues, the action of Na-K pumps is synchronized by T_3, T_4, TSH levels. In hypothyroidism, this enzyme is affected due to decrease potassium levels which leads to the water accumulation into the cells which results to edema(Murgod and Soans 2012) (Hanna and Scanlon 1997).

My research work showed that there were no statistical difference between thyroid hormones and electrolytes level except potassium ion levels in several thyroid dysfunction groups with different treatment period.

Correlation between thyroid hormones and electrolytes

We also interrelated the serum sodium and potassium ion levels with T_3, T_4, and TSH levels of healthy control and thyroid dysfunction groups. In healthy control individuals, there was a positive relationship among serum sodium ion and T_3 level and a negative relationship among serum potassium ion and T_3 level.

In hypothyroid outdoor patients, there was a positive association between serum sodium ion level and T_3 level and negative association between serum potassium ion and T_3 level. In hyperthyroid outdoor patients, there was a negative inter-relationship between serum sodium and potassium ion and T_3 level.

In healthy control groups, there was a positive relationship among serum sodium ion and T_4 level and a negative association among serum potassium ion and T_4 level.

In hypothyroid outdoor patients, there was a positive relationship among serum sodium ion and T_4 level and a negative association among serum potassium ion and T_4 level. In hyperthyroid outdoor patients, there was a negative association between serum sodium and serum potassium ion and T_4. In healthy control groups, there was a negative association between serum sodium and serum potassium ion and TSH level. In hypothyroid outdoor patients, negative association was observed between serum sodium ion and TSH level and positive association between serum potassium ion and TSH level.

Studies also showed the same correlation among serum potassium and sodium ion levels, and maximum TSH level. (Murgod and Soans 2012, Bharti, Shrestha et al. 2015). In hyperthyroid outdoor patients, there was a positive relationship between serum potassium ion level and TSH and a negative association was observed between serum potassium ion and TSH level.

Conclusion

It was concluded from my research work that thyroid dysfunctioning was more frequent in females than male individuals. Serum Sodium ion level was lowered in case of high TSH level and serum potassium ion level was higher in case of low TSH level. There was considerable statistical difference in T_3 level of hyperthyroid outdoor pateints with different age class. There was no statistical variation among thyroid hormones and serum electrolyte levels in various duration of treatment of hyperthyroid and hypothyroid outdoor patients except serum potassium ion level in hypothyroid outdoor patients. It suggests that patients having high TSH level and low TSH level should be checked frequently for the evaluation of serum electrolytes levels. Initial results and treatment can prevent advance problems.

Acknowledgments

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Figure Captions

Figure 1: Schematic diagram of experimental design

Figure 2: The levels of thyroid hormones including T_3, T_4 and TSH and electrolytes including $Na^+$and K^+ in male a-e), female individuals f-j)

Figure 3: The levels of thyroid hormones including T_3, T_4 and TSH and electrolytes including Na^+ and K^+ in normal individuals and thyroid patients with different age group

T3, b) T4, c) TSH, d) Na^+ and e) K^+

Figure 4: The levels of thyroid hormones including T_3, T_4 and TSH and electrolytes including Na^+ and K^+ in thyroid patients in various duration of treatment

T3, b) T4, c) TSH, d) Na^+ and e) K^+

Figure 5: Correlation of electrolytes levels including Na^+ and K^+ with thyroid hormones levels of healthy control individuals and study groups

a,b,c: T3 of control, Hypo-TF, and Hyper-TF respectively, d,e,f: T4 of control, Hypo-TF, and Hyper-TF respectively, g,h,i: TSH of control, Hypo-TF, and Hype-TF respectively.