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ORIGINAL ARTICLE

Medicine Science International Medical Journal

Medicine Science 2022;11(2):810-3

Analysis of the correlation between thyroid hormones and thyroid volume by gender: A volumetric computed tomography study

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Received 11 February 2022; Accepted 22 March 2022
Available online 28.03.2022 with doi: 10.5455/medscience.2022.02.037

Abstract

The aim of this study was to evaluate the correlation between triiodothyronine (T3), thyroxine (T4), and thyroid-stimulating hormone (TSH) hormones and thyroid gland volume with volumetric analysis performed by using computed tomography (CT) images. In this retrospective study, IV contrasted thoracic CT images taken for different indications between 2019 January and 2020 January were scanned from the archive system of the hospital. 67 (31F, 36M) individuals chosen randomly among patients whose CT results were reported as normal and who had taken thyroid hormone tests within the past week were included in the study. Images in Digital Imaging and Communications in Medicine format were transferred to the personal work station program (Horos Medical Image Viewer). By using the Region of Interest (ROI) console in the current program, a three dimensional model was obtained by drawing the border of the thyroid gland in sections varying between 15 and 25. Volume values of this three-dimensional model and TSH, T3, T4 values of the individuals were compared. While no correlation was found between thyroid gland volume and T3 and T4 hormones, a negative significant correlation was found with TSH. In terms of gender, thyroid gland volume, T3, T4 values were found to be statistically significantly higher in women when compared with men ($p \leq 0.05$). TSH value was found to be higher in women when compared with men ($p=0.005$). No statistically significant difference was found in T4 value ($p=0.057$). Radio-anatomical volumetric data of the thyroid gland presented in this study and its correlation with thyroid functions will be beneficial to clinicians working in the field in both internal and surgical medicine branches and will also guide future studies.

Keywords: Thyroid gland, computed tomography, TSH, T3, T4, volumetric analysis

Introduction

Knowing the thyroid size is important for the evaluation and treatment of thyroid disorders and its normal value may vary according to different geographical regions [1]. Due to ethnicity, age and sex related physiological factors and differences in body mass and growth rate among different populations worldwide, regional measurement scales and methodology have become necessary [1,2].

Thyroid gland can be easily accessed by sonography depending on its superficial anatomical location. Ultrasonography (US) is widely used in epidemiological studies as a rapid, safe and non-invasive technique to estimate thyroid volume [3]. Just like US, computed tomography (CT) and magnetic resonance imaging (MRI) provide structural information of the thyroid gland, but they are more costly [4]. On the other hand, small differences in US technique may cause important errors in thyroid volume measurements and variations between observers may be high even among experienced examiners [5]. On the contrary, CT has a very sensitive; therefore, it is a relatively accurate method of diagnosis and as a result, the number of CT examinations has increased greatly. However, CT should be administered with caution due to exposure to radiation and resulting risk of cancer [6,7].

Thyroid hormones regulate energy consumption and appetite. Triiodothyronine (T3) regulates metabolic and energy homeostasis and therefore affects body weight, thermogenesis and lipid metabolism [8]. Thyroid stimulating hormone (TSH) has receptors on preadipocytes and causes differentiation of preadipocytes into adipocytes, thereby expanding adipose tissue. On the other hand, substances such as leptin act on the central nervous system and can modulate neuroendocrine activity. [9].

In this study which was conducted on the normative data of thyroid

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gland volume obtained with CT, the effects of T3, thyroxinee (T4) and TSH on thyroid volume have been examined.

Materials and Methods

Image and Data Population

The study was initiated with the 2020/365 numbered decision of Karabük University non-interventional ethics committee. Patients who had IV contrasted thoracic CT with different indications between 2019 January and 2020 January were scanned retrospectively from the hospital archive. 67 (31F, 36M) individuals chosen randomly among patients whose CT results were reported as normal and who had taken thyroid hormone tests within the past week were included in the study. Patients who had a history of surgery in the neck area and those who were receiving thyroid hormone treatment were excluded from the study. The age range of the individuals in the study was 25-50 and mean age of the male patients was 40.92 years, while mean age of the female patients was 41.55 years. TSH, T3, T4 values obtained from the blood tests of all patients were recorded in excel.

Multidetector CT Protocol

MDCT scanner (Toshiba Medical Systems, Aquilion 16) was used for all patients. 3 mm reconstruction images were obtained from CT images with a section of 5 mm in the axial plane. Routine protocol prepared by system applicator for IV contrasted thoracic CT was used in scanning. The patients were given contrast material at appropriate dose according to their weight (300 mg iodine/ml). Scan protocol values were: gantry rotation: 0.75 s, tube voltage: 120 kV, pitch: 1.0 mm.

Image Analysis

Images in Digital Imaging and Communications in Medicine (DICOM) format were transferred to the Horos Medical Image Viewer (Version 3.0) workstation program. By using the Region of Interest (ROI) console in the current program, a three dimensional model was obtained by drawing the border of the thyroid gland in sections varying between 15 and 25 (Figure 1). Volume values of this three-dimensional model were recorded in excel.

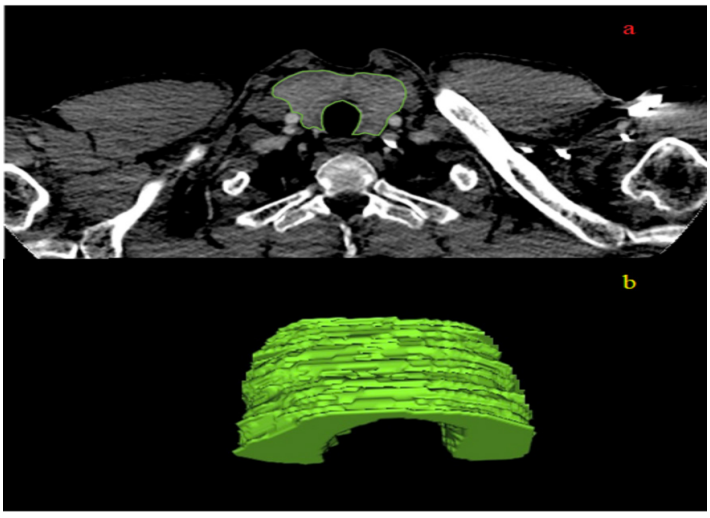

Figure 1. a) Sectioning from glandula thyroidea on CT axial images b) 3-D demonstration of glandula thyroidea

Data Analysis

Median, minimum and maximum values were used in the descriptive statistics of the data according to gender groups. Anderson Darling test was used as normality test. Mann-Whitney U test was applied to each parameter according to gender groups and p values were obtained. A significance value of $p \leq 0.05$ was used in the analyses. The correlation between parameters and the degree of correlation was tested with Spearman rho test. Minitab 17 package program was used in analyses.

Results

No differences were found in genders in terms of the ages of individuals in the study ($p=0.797$). Significant difference was found in the comparison of thyroid gland volume, TSH and T3 values according to gender ($p \leq 0.05$). No statistically significant difference was found in T4 value ($p=0.057$). Thyroid gland volume, T3, T4 values were found to be higher in men when compared with men. TSH value was higher in women when compared with men ($p=0.005$) (Table 1).

Correlation coefficient and p value of each parameter were found as a result of Spearman rho test applied to parameters. Negative correlation was expressed with "-", while positive correlation was expressed with "+". Data close to 1 shows strong correlation. Negative correlation was found between glandula thyroidea volume and TSH ($p \leq 0.05$). Negative significant correlation was found between TSH and T3 ($p \leq 0.05$). No significant correlation was found between the other parameters (Table 2).

Table 1. Descriptive statistics and Mann-Whitney U result table of the parameters (TSH: thyroid stimulating hormone, T3: triiodothyronin, T4: thyroxinee)

Parameters	Gender	Median (Min – Max)	P value
Thyroid gland volume (cm^3)	Male	16.69 (7.30–31.30)	0.034
	Female	12.02 (6.68–22.66)	
TSH (mIU/L)	Male	1.66 (0.42–14.43)	0.005
	Female	2.82 (0.44–10.10)	
T3 (pg/ml)	Male	3.31 (1.23–5.12)	0.031
	Female	3.08 (0.89–3.64)	
T4 (ng/dl)	Male	1.17 (0.89–2.24)	0.057
	Female	1.08 (0.79–1.51)	

Table 2. Correlation matrix table

Parameters	Thyroid gland volume	TSH	T3
TSH	-0.435 0.000		
T3	0.172 0.289	-0.318 0.049	
T4	0.082 0.577	-0.198 0.181	0.171 0.305

While the values above show the correlation coefficient, the values below show the p values

Discussion

In this study which was conducted to find out the correlation of thyroid gland volume with T3, T4 and TSH, thyroid gland volume and T3 values were found to be statistically higher in men when

compared with women. Although T4 values were higher in men, this result was not statistically significant. TSH value was found to be higher in women when compared with men. A negative significant correlation was found between thyroid gland volume and TSH and between TSH and T3.

US and CT are the most radiodiagnostic tools for the diagnosis of thyroid diseases. Although imaging is inexpensive, non-invasive and easy to use in US, the problems in the quality of images and the fact that measurements are affected by user create disadvantages [10]. CT can assess the whole thyroid gland at a glance and can include the mediastinal component of thyroid gland without any problems. In addition, measurement and standardization of volume is easier with CT, it does not require additional software and it has good reproducibility with little inter-observer variability [11].

In a study which evaluated thyroid gland volume with US and CT in preoperative period, measurements were repeated in intraoperative period and when compared with US examination, it was concluded that thyroid gland volume obtained from the three-dimensional reconstruction of neck CT was statistically significantly more successful [12].

In literature review, it was found that a study conducted by Dong He Lee et al. (2004) reported that there was no statistically significant difference in thyroid gland volume between genders [2]. There are also studies which have reported that thyroid gland size is higher in women when compared with men [13, 14]. In our study, in measurements made from 3 dimensional models obtained from CT images, thyroid gland volume of men was found to be statistically higher than that of women. The fact that there is no consensus in literature on this may be resulting from methodological, environmental and racial differences.

Iodine use of thyroid gland decreases as age increases and increasing TSH causes an increase in thyroid size. In a study which reported that thyroid size increases with age, it was reported that this is a situation that occurs especially after the fourth decade [2]. In our study, since the mean age of men was 40.92 years and mean age of women was 41.55 years, we believe that our results were not affected by the negative effects of age on thyroid gland volume.

In a study conducted in 2008, it was reported that the risk of recurrent laryngeal nerve injury and therefore voice disturbance risk increased as thyroid gland volume increased. Anatomical information about thyroid gland volume is also important for laryngeal stenosis [15].

Although there are studies in literature on thyroid function tests, it can be seen that their relationship with thyroid gland volume has not been examined. While this is a limitation for our discussion, we believe that our study will create a basis for new research.

In a study conducted on patients with Hashimato hypothyroid, no statistically significant difference was found between thyroid gland volume and serum TSH levels [16]. However, negative significant correlation was found between thyroid gland volume and TSH in our study.

Physiological factors known to affect thyroid size, harmful habits have been reported [17]. Since our study was conducted retrospectively, it is a limitation that these factors were not considered. The fact that the clinical states of patients were not questioned can be considered as another limitation. In this respect, more comprehensive prospective studies which evaluate volumetric measurements with clinical findings of patients are required.

Conclusion

Due to high prevalence of thyroid-related conditions, anatomical volume information of thyroid gland and the correlation of this with thyroid functions are important for clinicians performing surgery in this area. We believe that the data found in our study will be useful for clinicians interested in thyroid gland in both internal and surgical medicine.

Conflict of interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical approval
The study was initiated with the 2020/365 numbered decision of Karabük University non-interventional ethics committee.

Patient informed consent
Since this article is an original article and a retrospective study, an informed consent form is not required.

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