Study of thyroid volume by ultrasonography in clinically euthyroid patients

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Abstract

Introduction: The purpose of this study was to establish reference ranges of total thyroid volume among clinically euthyroid Nepalese population using Ultrasonography and correlate this volume with age, sex, individual’s built and geographic location.

Methods: This was a prospective cross sectional study involving 485 clinically euthyroid individuals. B-mode Ultrasonography was used to measure the total thyroid volume by combining the volume of both the lobes obtained by using formula for prolate ellipsoid. Age specific reference values for thyroid volume were obtained and Pearson correlation test was used to see the relationship with various factors.

Results: Among 485 individuals between 1 to 83 years of age, 221(45.57%) were males and 264(54.43%) were females. Maximum [354 individuals (72.99%)] were from hilly region and minimum [16 individual (3.30%)] were from Himalayan region. Mean thyroid volume was 6.629 ± 2.5025 ml. In general, thyroid volume was found to be more in older individuals than in young age group. There was no significant difference of thyroid volume between males and females. Thyroid volume best correlated with body surface area (r=0.444, p<0.0001). The volume had a positive correlation with weight (r=0.443, p<0.0001), body mass index (r=0.371, p<0.0001) and height (r=0.320, p<0.0001) of the individual.

Conclusions: This study estimated the reference range of total thyroid volume for Nepalese population. These ranges are significantly lower than the WHO/ICCIDD thyroid volume references and reference values obtained in various other countries. Total thyroid volume best correlated with Body surface area.

Keywords: Body surface area, clinically euthyroid, total thyroid volume, ultrasonography

Introduction

Thyroid is a vital endocrine gland of our body which is located superficially in the infrahyoid compartment of neck in a space outlined by muscle, trachea, esophagus, carotid arteries and jugular veins. It lies against C5 to T1 vertebral level.1 It is involved in the production, storage and release of thyroid hormones thyroxine (T4) and triiodothyronine (T3). Thyroid hormones are required for various physiological actions in the body including regulation of body metabolism. They are the essential hormones for the growth and development of the individual.

The size and shape of the gland varies widely in normal individuals. Normally in tall individuals, the lobes have an elongated shape where as in shorter individuals they are oval. As a result, the normal dimensions of the gland have wide variability.1 Besides a number of physiological and pathological factors affect thyroid volume. Many factors influence the size of the thyroid gland, among which age, sex, body mass index, body surface area, iodine etc. are of
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importance. These factors seem to interact in a complex way. A profound negative relationship between increasing iodine intake and goiter prevalence is incontestable.

Estimation of the thyroid volume is generally considered to be important in several pathologic situations such as iodine deficiency goiter, thyroiditis, multinodular goiter, and others. For example, it allows evaluation of the efficacy of suppressive levothyroxine therapy in thyrotoxicosis during their follow-up. Quite recently in addition, it increases interest because of the introduction of minimally invasive surgery that requires the most correct evaluation of the mass of the gland on which to operate. Indeed, the main limiting factor when selecting patients for minimally invasive procedures is the gland mass, which should not exceed 20 ml volume.

There are various methods of estimating thyroid size and volume like palpation, ultrasonography, radionuclide study, computed tomography etc. As this gland is located superficially, it can be easily palpated. There is disagreement about which system of palpation best describes the size of the thyroid gland: one based on estimated weight or one based on other variables, such as the presence of a visible prominence. The paucity of data comparing different methods of thyroid examination or size determination makes it difficult to recommend the use of one method over another.

It has been suggested that the ultrasonographic estimation of thyroid volume would overcome the problems of overestimation of goiter prevalence and marked interobserver variability associated with palpation estimates. Thyroid ultrasonography has proven a useful and practical method for the assessment of thyroid size. The availability of portable ultrasound equipment has facilitated its application to epidemiological studies. Apart from measurement of the thyroid size, ultrasound can detect non palpable nodules, estimate the size of the nodule and characterize the nodule.

In many of the western as well as our neighbouring countries, sonographic study has been done to assess the thyroid volume in children and adults. Various investigators have measured thyroid volume and have found different values for normal euthyroid patients. Hegedus L, et al. in a study showed that in adult, the mean thyroid volume is 18.6 +/- 4.5ml (M = 19.6 +/- 4.7ml, F= 17.5 +/- 4.3ml). This converts to 18.6gm. Similarly Ivanac G et al found mean thyroid volume of 10.68 +/- 2.83 ml (range 5.71 – 17.09ml).

In Nepalese population, the volume of the gland has not been established till date. The reference of the thyroid volume in our population is still based on western data. Before applying size criteria to diagnose the goitre, we have to establish the normal range of size of the gland in relation to age, sex, weight, height and geographical region where one resides as it is a known fact that thyroid volume is greatly influenced by these factors.

So this study was done in an attempt to establish the thyroid volume in normal Nepalese population in relation to age, sex, weight, height, body surface area, body mass index and geographic region.

Methods

This was a prospective cross sectional study involving 485 cases without any known thyroid disease or symptoms related to thyroid disease. The study was conducted in the Department of Radiology and Imaging, Tribhuvan University Teaching Hospital (TUTH) from September 2007 to August 2008.

Persons without signs and symptoms of thyroid disease irrespective of the age and sex who presented in the various departments of TUTH were included in the study. Patients with known thyroid disease, presence of thyroid nodule causing enlargement of thyroid gland, heterogeneous echotexture of thyroid gland and increased vascularity of the gland were excluded from the study.

Patient who came for Ultrasonography examination, for various reasons other than thyroid problems, were included in the study after obtaining informed consent. Detail information was recorded in the pre designed data collection sheet. Information included were particulars of the patients, history regarding thyroid symptoms, demographic location of the individual. Demographic location was assigned as per the division of country into Himalayan region, hilly region and Terai region. Patients’ height in meters and weight in kilograms were recorded.

Body mass index (BMI) of the patient was obtained by using the formula:

\[ BMI = \frac{weight \text{ in Kg}}{height \text{ in m}^2} \]

Body surface area (BSA) was obtained by using Mosteller formula:

\[ BSA \text{ (m}^2) = \frac{\text{height in cm.set weight in kg}}{3600} \]

All the individuals were examined in the supine position with the neck hyperextended. Using a linear 7.5 MHz probe in SONOACE 8000 LIVE machine, transverse and longitudinal sections of both lobes of the thyroid gland were scanned. Measurements of the maximum length of the lobe from the sagittal images were recorded. The maximum transverse diameter (breadth) and the maximum depth of
The volume of each lobe was calculated automatically by the machine using the formula for a prolate ellipsoid, where

\[ \text{Thyroid volume} = \text{length} \times \text{breadth} \times \text{depth} \times \frac{\pi}{6}. \]

Total thyroid volume was obtained by adding the volume of both the lobes. Volume of isthmus was not included in the total thyroid volume.

Data obtained were compiled and analyzed using standard statistical analysis. SPSS 11.5 and Microsoft Excel were utilized for the data analysis and presentation. Pierson correlation was used to see the relation of various demographic parameters with total thyroid volume. Independent t-test was used to calculate the significance between sex groups and different demographic groups. Paired t-test was used to compare the difference between the volumes of two lobes of the gland in the same individual.

### Results

The thyroid gland volume was estimated in all 485 individuals. Characteristics of the study population are shown in figures 3, 4 and 5. Mean age was 34.06 years (range 1-83 years). Maximum number of individuals (34.02%) were in the age group of 20-29 years. Lowest number of individuals (1.03%) were in the age group of above 80 years. Out of 485 individuals, 221 individuals (45.57%) were males and 264 individuals (54.43%) were females. Among all 16 individuals (3.30%) were from Himalayan region, 354 individuals (72.99%) were from hilly region and 115 individuals (23.71%) were from Terai.

**Fig. 1:** Measurement of volume of right lobe of thyroid gland.

**Fig. 2:** Measurement of volume of left lobe of thyroid gland.

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Total thyroid volume was obtained by adding the volume of both the lobes. Volume of isthmus was not included in the total thyroid volume.

Data obtained were compiled and analyzed using standard
Thyroid volume:
Calculated mean total thyroid volume was 6.629 ± 2.5025 ml (=6.629 ± 2.5025 g). Right lobe volume was 3.7910± 0.06647ml while that for left lobe was 2.8367 ± 0.05435 ml. Right lobe had significantly higher volume than the left (p<0.0001). Maximum thyroid volume was 24.95 ml and minimal volume was 1.59 ml.

Table 1: Volume of thyroid gland

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total volume</td>
<td>485</td>
<td>6.629</td>
<td>2.5025</td>
<td>0.1136</td>
</tr>
<tr>
<td>Right lobe</td>
<td>485</td>
<td>3.7910</td>
<td>1.46374</td>
<td>0.06647</td>
</tr>
<tr>
<td>Left lobe</td>
<td>485</td>
<td>2.8367</td>
<td>1.19699</td>
<td>0.05435</td>
</tr>
</tbody>
</table>

Age specific reference values:
The reference values of total thyroid volume for different ages are shown in Table 2. The total thyroid volume increased with increasing age of the patient upto 80 years (r = 0.292, p <0.0001) with highest value of 8.504706 ± 4.915199 ml for the age group of 70 to 79 years.

Table 2: Age specific reference values for total thyroid volume.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Sample size (n)</th>
<th>Mean</th>
<th>Total thyroid volume (ml)</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10</td>
<td>16 (3.29%)</td>
<td>1.785</td>
<td>0.769251</td>
<td></td>
</tr>
<tr>
<td>10-19</td>
<td>46 (9.69%)</td>
<td>5.113043</td>
<td>1.78792</td>
<td></td>
</tr>
<tr>
<td>20-29</td>
<td>165 (34.02%)</td>
<td>6.643636</td>
<td>1.87136</td>
<td></td>
</tr>
<tr>
<td>30-39</td>
<td>107 (22.06%)</td>
<td>7.220093</td>
<td>2.108951</td>
<td></td>
</tr>
<tr>
<td>40-49</td>
<td>59 (12.16%)</td>
<td>6.988644</td>
<td>2.16853</td>
<td></td>
</tr>
<tr>
<td>50-59</td>
<td>47 (9.69%)</td>
<td>6.497872</td>
<td>1.705072</td>
<td></td>
</tr>
<tr>
<td>60-69</td>
<td>23 (4.74%)</td>
<td>8.123043</td>
<td>4.185859</td>
<td></td>
</tr>
<tr>
<td>70-79</td>
<td>17 (3.50%)</td>
<td>8.504706</td>
<td>4.915199</td>
<td></td>
</tr>
<tr>
<td>80+</td>
<td>5 (1.03%)</td>
<td>6.644</td>
<td>1.989354</td>
<td></td>
</tr>
</tbody>
</table>

Thyroid volume and Sex
Total thyroid volumes for males and females were 6.849 ± 2.7448 ml and 6.444 ± 2.2689 ml respectively. The difference in values were not significant (p= 0.076).

Thyroid volume and demographic location
Thyroid volume for individuals from Himalayan region was highest (mean 8.958± 3.6314ml) and it was lowest for those from Terai region (mean 6.364± 1.9598 ml).
Mean thyroid volume of individuals from Himalayan region was significantly higher than that from hilly and Terai region (p < 0.0001). Difference of thyroid volume between individuals from hilly and Terai region was not significant (p = 0.345).

**Thyroid volume and individuals built**

Total thyroid volume significantly correlated with individual’s height, weight, body mass index and body surface area (p<0.0001). Highest correlation was found with body surface area (r = 0.444).

**Table 3**: Correlation of total thyroid volume with various parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pearson correlation</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>0.443</td>
<td>0.000</td>
</tr>
<tr>
<td>Height</td>
<td>0.320</td>
<td>0.000</td>
</tr>
<tr>
<td>BMI</td>
<td>0.371</td>
<td>0.000</td>
</tr>
<tr>
<td>BSA</td>
<td>0.444</td>
<td>0.000</td>
</tr>
<tr>
<td>Age</td>
<td>0.292</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Total thyroid volume is increased with increasing body mass index (Fig. 8) and body surface area (Fig. 9).

**Discussion**

We estimated the reference values of total thyroid volume based on ultrasonographic measurements of thyroid gland for Nepalese population based on the cross sectional observations in total 485 individuals. Relation of total thyroid volume with age, sex, height, weight, body mass index, body surface area and geographic location of the individuals were studied.

**Total thyroid volume**

The study showed that the mean total thyroid volume was 6.629 ± 2.5025 ml. This value is lower than that obtained by Hegedus L et al,10 Chanoine JP et al16 and Ivanac G et al15. In the study done by Hegedus L et al mean thyroid volume was 18.6±4.5ml. All the subjects in our study had thyroid volume lower than the mean thyroid volume obtained by Hegedus L et al10, Chanoine JP et al16 and Ivanac G et al15. In the study carried out by Chanoine JP et al mean thyroid volume was 2.7(0.8) in prepubertal subjects aged 8-11 years and 11.6 (4.4) ml in late pubertal subjects aged greater than 17 years.10 Mean thyroid volume obtained by Ivanac G et al from 51 females aged 20 to 38 years (mean 22) was 10.68 ±2.83 ml.15 Increasing use of iodine supplementation in our country in the recent years could be one of the factors reducing the iodine deficiency prevalent in the country and thus reducing the total thyroid volume.
Considerable discrepancy exist between the size of right and left lobes of thyroid gland in individual. In our study, right lobe of the thyroid gland had significantly higher volume than the left lobe (3.7910± 0.06647ml vs 2.8367 ± 0.05435 ml). No explanation was found for this difference.

**Age-specific thyroid volume**

We have calculated age specific thyroid volume. In general, thyroid volume increased with increasing age of the individual. This finding is similar to various other studies. In a study done by Chanoine JP et al in 256 euthyroid subjects aged 0 to 20 years total thyroid volume increased significantly (p<0.001) until the age of 8 years without influenced by sex and thereafter varied widely. Dvoráková M et al showed the age-related increase of the volume of thyroid gland at both sexes (F-ratio = 1.99, p < 0.0001). However, our age specific reference values are lower than the reference values obtained by various researchers. In the study carried out by Chanoine JP, et al mean thyroid volume was 2.7(0.8) in prepubertal subjects aged 8-11 years and 11.6 (4.4) ml in late pubertal subjects aged greater than 17 years. Our age specific reference values are also lower than WHO/ICCIDD thyroid volume references.

**Thyroid volume and sex**

We didn’t find any significant difference in total thyroid volume between males and females. Similar observations were made by F Xu et al. A number of other studies based on ultrasonography in iodine sufficient areas have also found no difference by sex. However, Hegedus L et al found a significant difference in volume between males (19.6±4.7ml) and females (17.5±4.2ml). The difference in thyroid gland volume between males and females was solely explained by body weight.

**Thyroid volume and demographic location**

It is a well known fact that iodine deficiency is one of the major factors of enlargement of thyroid gland and dietary iodine is different in different geographic locations. In a geographic area where mild iodine deficiency is common, a significant relation between iodine intake and thyroid volume exists. Generally iodine content is lower in the high mountain regions. Himalayan region and hilly region of our country are such areas.

We found significantly higher thyroid volume in the Himalayan sample as compared to hilly and Terai samples. However, the difference of mean thyroid volume was not significant between hilly region and Terai region. Migration of the individuals within the country and more effective supplementary iodine in the hilly and Terai region may be the factors responsible for this difference.

**Thyroid volume and Body surface area**

In our study, thyroid volume was best correlated with body surface area (r=0.444, p<0.0001). Thyroid volume increased with increasing body surface area. This observation is similar to that obtained by other researchers. In the study performed by Irene Kaloumenou et al, total thyroid volume significantly correlated with BSA in boys (r=0.730, p<0.0005) and girls (r=0.623, p<0.0005). In another study done by Chanoine JP et al, the volume was best correlated with body surface area (p<0.01). Narseta Mickuviené et al also found body surface area as the best indicator of thyroid volume assessment and recommended using the criteria based on body surface area in order to evaluate the constitutional characteristics of individual child’s development. Similar observations were made by Svensson J et al.

**Thyroid volume and height**

We found significant positive correlation between total thyroid volume and height of the individual (r=0.320, p<0.0001). This observation is similar to the study done by Ivanac G et al. In their study, thyroid volume was best correlated with body height (r=0.37; p=0.001).

**Thyroid volume and weight**

In our study, thyroid volume was best correlated with weight of the individual after body surface area (r=0.443, p<0.0001). This finding is in consistent with the findings of Hegedus L et al Ramazan Sari et al and Svensson J et al. In the study done by Hegedus L et al, the difference in total thyroid volume between males and females was solely explained by weight. There was a positive correlation between the changes of thyroid volume and the change of body weight (r=0.341, p=0.009) in the study done by Ramazan Sari et al.

**Thyroid volume and Body Mass Index (BMI)**

We found significant positive correlation of total thyroid volume with body mass index (r=0.371, p<0.0001). This observation is similar to that found by Ramazan Sari et al. In their study, there was positive correlation of total thyroid volume with BMI (r=0.504, p<0.001). However, our observation is in contrast to that by Irene Kaloumenou et al who found minimal correlation of total thyroid volume with BMI (r=0.166, p=0.023).

**Conclusions**

This study estimated the age specific reference values for thyroid volume in Nepalese population which will be useful in the clinical practice especially for the diagnosis of goiter.
The estimated mean thyroid volume in our population is seen to be significantly lower compared to the thyroid volume in the western population showed by different studies done in the west and other different countries.

Thyroid volume best correlated with Body surface area followed by weight and body mass index. Thus body surface area specific reference values would be the best reference values for the use in clinical practice for evaluation of thyroid volume.

Significant difference in thyroid volume is found between the individuals from different geographic region of the country with highest values seen in population of the Himalayan region.

Limitations of our study:
1. Small sample size
2. Disproportionate demographic representation
3. Disproportionate age representation
4. Other accurate modalities for volume estimation like radionuclide and 3D ultrasound were not considered in our study

References
in adults aged 18-65 years in the Czech Republic—determination of the norms, Vnitr Lek. 2006 Jan;52(1):57-63.


