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Ultrasonography Estimated Thyroid Volume: A Prospective Study About its Reliability

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Ultrasonography is supposed to provide a reliable preoperative estimate of thyroid volume. This prospective study compares the estimated thyroid volume (EV) to real volume (MV), obtained by measuring the excised gland after surgery. One hundred one patients undergoing total thyroidectomy were selected for the study. Indications for surgery were: multinodular goiter, diffuse toxic goiter (DTG), uninodular disease. In all cases, ultrasound was repeated 1 month after surgery to verify complete thyroid removal. EV was underestimated in 89 cases; it perfectly matched the MV in 5 and was overestimated in 7. Mean EV was 28.3 mL (range, 7–50) and mean MV 36.2 mL (range, 7–76); this difference was statistically significant ($p < 0.0001$). Patients were then divided in groups according to EV (< or > than 25 mL) and thyroid morphology. Highly significant differences were found between all groups ($p < 0.0001$) except the DTG population, where the difference was less significant ($p < 0.042$). The study demonstrates that a correct preoperative measurement of the thyroid gland is not achievable because the volume estimated by ultrasound is largely underestimated in comparison to the real volume of the excised gland. Nevertheless ultrasound is more reliable in DTG than in other thyroid diseases. Increasing the number of cases may help to verify a new mathematical model.

Introduction

THE POSSIBILITY OF OBTAINING an estimate of the thyroid volume is generally considered to be important in several pathologic situations such as thyroiditis, multinodular goiter, and others. For example, it may allow to evaluate the efficacy of suppressive levothyroxine therapy 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 (1,2). The volume estimate is currently performed by means of an ultrasound (US) examination of the neck using a mathematical formula (3–5), but the reliability of such an evaluation has been verified only rarely (4). The only possibility of receiving correct feedback information about thyroid volume can be obtained measuring the surgical specimen after its removal and comparing it with its preoperative value. This prospective study aims to compare the estimated volume (EV), as determined by preoperative US, and the real gland volume (measured volume [MV]), as obtained by measuring the surgical specimen after total thyroidectomy. Only patients undergoing total thyroidectomy entered the study, in order to avoid the possible error introduced by summing measurements obtained by different methods (4).

Materials and Methods

From a cohort of 700 patients undergoing total thyroidectomy during the last 4 months, 101 whose EV did not exceed 50 mL were selected. Their mean age was 44.57 years (range, 8–76); there were 22 males and 79 females. The 50 mL cutoff was established in order to avoid glands with a mediastinal portion that could have escaped at preoperative evaluation. Indications for thyroidectomy were represented by multinodular goiter (hyperfunctioning or not) in 63 cases, diffuse toxic goiter in 10, uninodular malignant pathology in 28. Eighty patients were euthyroid at the time of operation, whereas thyrotropin (TSH) was suppressed by levothyroxine therapy in 21 patients. EV was estimated preoperatively by the same ultrasonographer, using the same 7.5-MHz probe. A mathematical formula was adopted: it approximates the thyroid lobes to ellipsoids and their volume is subsequently calculated as follows:

$$\text{VOLUME} = \pi/6 \times (a \times b \times c)$$

where a, b, c represent the length of the main axes determined from the ultrasonic sections. Total thyroid volume is

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TABLE 1. COMPARISON OF PATIENTS DIVIDED BY EV

	Mean EV (SD)	*Mean percent difference*	p
Group 1 (0–25 mL) (n = 43)			
Estimated	16.2 (5.1)	26.0	0.0001
Actual	22.8 (7.8)		
Group 2 (≥ 25 mL) (n = 58)			
Estimated	37.2 (5.6)	16.1	0.0001
Actual	46.2 (14.2)		

EV, estimated thyroid volume; SD, standard deviation.

obtained by summing the volumes of both lobes. The isthmus is not taken into account in volume calculation.

Total thyroidectomy was performed in all cases through a conventional cervicotomy by the same surgeon and the thyroid was removed in one piece. MV was calculated by adding water into a graduated cylinder until the level of 100 mL was reached. The amount of water added was considered to be the real thyroid volume. In all patients, US was performed 1 month after surgery to confirm the completeness of the thyroidectomy.

Patients were divided into two groups with regard to the size estimated by US: less or more than 25 mL; this value represents half of the maximum volume (50 mL) chosen as a cutoff for the selection of patients in the present study (Table 1). They were also divided in three groups with regard to thyroid morphology: multinodular, uninodular or diffuse goiter (Table 2).

Data were expressed as mean and standard deviation; differences between actual and estimated size were computed by a paired sample t test.

Data were analyzed using SPSS/PC + 11.5 statistical software (SPSS Inc., Chicago, IL).

Results

The EV was underestimated in 89 cases; it perfectly matched the MV in 5 cases and it was overestimated in 7 cases. When evaluating the total sample mean EV resulted to be 28.3 mL (range, 7–50) and mean MV was 36.2 mL (range, 7–76); this difference was statistically significant ($p < 0.0001$).

When patients were divided on the basis of the EV (less than 25 mL—between 26 and 50 mL), the mean difference between EV and MV expressed in percentage was statistically significant for both groups ($p < 0.0001$). This difference was relatively greater comparing EV and MV in the first group where thyroid volume was lower than 25 mL.

When patients were analyzed on the basis of the different thyroid pathology profiles, differences between EV and MV were also statistically significant: $p < 0.0001$ for multinodular and uninodular disease, and $p < 0.042$ for the populations presenting with diffuse thyroid disease (Table 2).

No statistically significant difference was present comparing the hormonal profile of patients (normal or suppressed TSH), gender, and age.

Discussion

The purpose of this study was to establish whether preoperative US was suitable to evaluate thyroid volume correctly in order to make decisions, in particular when selecting patients for minimally invasive procedures, where gland volume is the most important cutoff parameter in patient selection. Another important reason to obtain an exact thyroid volume measurement is the necessity of monitoring the gland and the nodule growth in patients undergoing suppressive therapy for multinodular goiter (7). Not only suppressive therapy but also radioactive iodine therapy in patients with Graves' disease could greatly profit from precise thyroid EV, which is an important parameter for assessing the dosage schemes (8).

This single study demonstrates that a statistically significant error in the estimation of the thyroid volume, as assessed by preoperative US, occurs in 94.1% of the cases. However, it was also important to determine whether there was a precise trend toward an underestimate or an overestimate. From this series, it would clearly appear that underestimation (89 cases of 101; 88.1%) was the most frequent error in most cases, but not in all.

When analyzing data with regard to the EV (dividing thyroid gland volumes in two groups), results showed a decreased percentage of error when larger volumes are analyzed (Table 1). Thus, the impression is that the accuracy of US determination increases with increasing volumes.

Being aware of this might be important while selecting patients for endoscopic thyroid procedures, that could meet with failure just because of underestimation of the thyroid volume. It is also important to note that this trend would probably disappear when dealing with large goiters because of the possible presence of substernal extension: in these cases, a computed tomography (CT) scan seems to give better thyroid volume measurements (9).

TABLE 2. COMPARISON OF EV AND MV IN EACH DISEASE SUBGROUP

	Mean volume (mL) (SD)	p
Diffuse toxic goiter (n = 10)		
Estimated	33.4 (10.7)	0.042
Actual	39.6 (13.9)	
MNG (n = 63)		
Estimated	31.9 (11.9)	0.0001
Actual	41.5 (16.1)	
UN (n = 28)		
Estimated	18.3 (8.3)	0.0001
Actual	23.2 (10.6)	

SD, standard deviation; MNG, multinodular goiter; UN, uninodular disease.

On the other hand, no difference was found when analyzing hormonal profiles: the slight difference found in the diffuse toxic goiter subgroup ($p < 0.042$) compared to uninodular and multinodular disease ($p < 0.0001$) can probably be accounted for by more regular profiles of the gland. The irregular shape of multinodular glands clearly affects the theoretical model of an ellipsoid, used for the US measurement of thyroid volume.

The study suggests that a correct preoperative estimate of the thyroid volume might be achieved introducing a mathematical adjustment in the formula used for the measurement. Therefore, it would be advisable to improve the method currently available. It must be stressed that an adjustment could also increase the error in all those cases where EV had been overestimated (7% of patients). However, the discrepancy is not enormous and probably does not affect most studies, such as epidemiological evaluation in areas of goiter prevalence (6,10). On the other hand, surgeons should be exactly aware of a possible US preoperative underestimation when selecting patients for endoscopic surgery on the basis of their gland volume. In order to obtain a more correct preoperative evaluation, the best way would be to search for a better mathematical model that takes into account the irregular shape of an abnormal thyroid gland.

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