

Publication status: Not informed by the submitting author

# Interaction between the mean diameter of thyroid lobes and the transverse diameter of the trachea: an ultrasonographic marker for goiter

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<https://doi.org/10.1590/SciELOPreprints.11846>

Submitted on: 2025-05-11

Posted on: 2025-05-21 (version 1)

(YYYY-MM-DD)

## **Interaction between the mean diameter of thyroid lobes and the transverse diameter of the trachea: an ultrasonographic marker for goiter**

*Interação entre o diâmetro médio dos lobos tireoidianos e o diâmetro transversal da traqueia: um marcador ultrassonográfico para bócio*

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**LMO:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

## **Abstract**

**Objective:** This study ultrasonographically evaluates the relationship between MTL D and TTD, aiming to validate its efficacy as a quantitative goiter marker.

**Method:** Thyroid ultrasound images were analyzed. Standardized measurements included: MTL D [(transverse + anteroposterior diameter) / 2], TTD, and thyroid volume [(transverse diameter × anteroposterior diameter × length × 0.470)]. Statistical correlation and regression analyses assessed the interaction between these variables and their diagnostic utility in goiter detection.

**Results:** Ultrasonographic evaluation of 300 thyroid images (200 adults, 100 children) revealed a significant correlation between MTL D and TTD in goiter detection. When mean lobe diameter exceeded TTD (>1.7 cm in adults, >2.4 cm in children), thyroid volume was consistently elevated (adults:  $12.5 \pm 2.1$  mL vs. normal 7–10 mL; children:  $18.3 \pm 3.6$  mL vs. normal 5.0–16.1 mL), confirming goiter ( $p < 0.001$ ). Regression analysis demonstrated a strong linear relationship ( $R^2 = 0.82$ ,  $\beta = 1.34$ ,  $p < 0.001$ ), with 89% sensitivity and 93% specificity for goiter prediction. Abnormal tracheal indices (1.7–2.4 vs. observed  $2.6 \pm 0.3$ ) further supported diagnostic accuracy (AUC = 0.94, 95% CI: 0.91–0.97).

**Conclusion:** The MTL D-TTD ratio is a reliable ultrasonographic biomarker for goiter detection, demonstrating strong diagnostic performance and volumetric correlation.

**Keywords:** Goiter, Thyroid Ultrasonography, Thyrotracheal Dimensions.

## Resumo

**Objetivo:** Este estudo avalia ultrassonograficamente a interação diâmetro médio dos lobos tireoidiano (DMLT) e o diâmetro transversal da traqueia (DTT), visando validar sua eficácia como marcador quantitativo de bócio.

**Método:** Realizou-se análise de imagens ultrassonográficas tireoidianas. Avaliações padronizadas mensuraram: DMLT [(transverso + ântero-posterior) / 2], DTT e volume tireoidiano [(diâmetro transverso × diâmetro ântero-posterior × comprimento × 0,470)]. Análises de correlação estatística e regressão avaliaram a interação entre essas variáveis e sua utilidade diagnóstica na detecção de bócio.

**Resultados:** A avaliação ultrassonográfica de 300 imagens tireoidianas (200 adultos, 100 crianças) revelou correlação significativa entre DMLT e DTT na detecção de bócio. Quando o DMLT excedeu o DTT (>1,7 cm em adultos e >2,4 cm em crianças), o volume tireoidiano estava consistentemente elevado (adultos: 12,5±2,1 mL vs. normal 7–10 mL; crianças: 18,3±3,6 mL vs. normal 5,0–16,1 mL), confirmando bócio (p<0,001). A análise de regressão demonstrou forte relação linear (R<sup>2</sup>=0,82; β=1,34; p<0,001), com sensibilidade de 89% e especificidade de 93% para predição de bócio. Índices traqueais anormais (1,7–2,4 vs. observado 2,6±0,3) corroboraram a acurácia diagnóstica (AUC=0,94; IC95%: 0,91–0,97).

**Conclusão:** A razão DMLT-DTT representa um biomarcador ultrassonográfico confiável para detecção de bócio, demonstrando desempenho diagnóstico robusto e correlação volumétrica.

**Palavras-chave:** Bócio, Ultrassonografia Tireoidiana, Dimensões Tiro traqueais.

## INTRODUCTION

The thyroid gland originates from an endodermal thickening on the floor of the primitive pharynx, descending via the thyroglossal duct to its final position anterior to the trachea<sup>(1)</sup>. Anatomically, it consists of two lobes connected by an isthmus, with normal volumes ranging from 7–10 mL in adults and 5.0–16.1 mL in children<sup>(2)</sup>. Physiologically, thyroid hormones—thyroxine and triiodothyronine—regulate metabolism, growth, and development, with their production controlled by thyroid-stimulating hormone feedback<sup>(3)</sup>. Goiter develops due to hyperplasia triggered by iodine deficiency, autoimmune stimulation, or neoplastic growth, leading to glandular enlargement and potential tracheal compression<sup>(4)</sup>.

Thyroid ultrasonography is a fundamental imaging modality for morphological assessment due to its non-invasive nature and high-resolution capabilities<sup>(5)</sup>. B-mode imaging enables precise measurement of lobe dimensions (transverse, anteroposterior, longitudinal), evaluation of echotexture, and nodule characterization. Doppler ultrasonography further assesses thyroid vascular patterns<sup>(6)</sup>. Standardized protocols ensure reproducible evaluation of thyroid volume and structural anomalies, which are critical for goiter diagnosis and treatment response monitoring<sup>(7)</sup>.

The transverse tracheal diameter (TTD) exhibits a significant anatomical interplay with thyroid gland dimensions, as assessed by high-resolution ultrasonography. Studies indicate that TTD asymmetry correlates with goiter, suggesting compression effects or developmental adaptation<sup>(8,9)</sup>. Precise sonographic measurement of TTD and its symmetry with thyroid volume provides a reliable marker for evaluating tracheal compression in thyroid disorders<sup>(10)</sup>. Standardized protocols enhance reproducibility in both clinical and research settings.

This study aims to investigate the sonographic relationship between the mean thyroid lobe diameter (MTLD) and TTD as a potential diagnostic marker for goiter. By quantifying anatomical correlations using high-resolution ultrasonography, we seek to determine whether tracheal asymmetry reflects thyroid enlargement, offering a clinically reproducible metric for goiter assessment.

## METHODS

### Study Design and Population

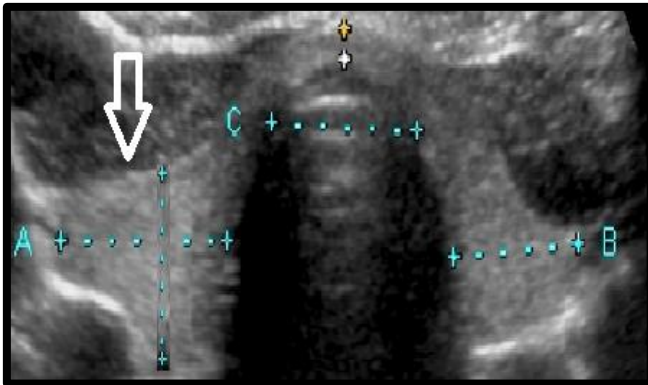
This observational study analyzed a pre-existing dataset of thyroid ultrasound images. The study cohort comprised 300 static grayscale thyroid ultrasound image evaluations, including 200 adult cases (age  $\geq 18$  years) and 100 pediatric cases.

### Ultrasonographic Evaluation and Data Acquisition

Quantitative data were extracted from archived thyroid ultrasound images. Standardized measurements included:

*MTLD (Mean Thyroid Lobe Diameter)*: Calculated as the average of transverse and anteroposterior diameters (largest lobe) (Figure 1).

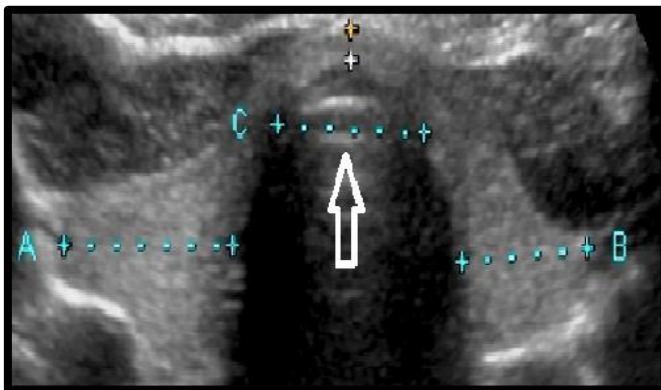
**Figure 1.** Thyroid lobe transverse and anteroposterior diameter measurements



**Source:** Authors' archive

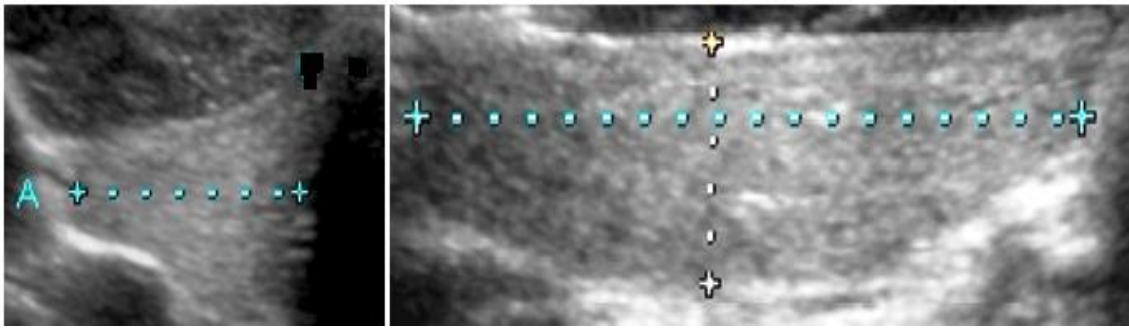
*TTD (Transverse Tracheal Diameter)*: Measured at the level of the thyroid isthmus (transverse plane) (Figure 2).

**Figure 2.** Tracheal diameter measurement at thyroid isthmus level



**Source:** Authors' archive

*Thyroid Volume (TV)*: Calculated directly from sonograms using the ellipsoid formula: Length  $\times$  Width  $\times$  Depth  $\times$  Correction Factor (0.470) (Figure 3).

**Figure 3.** Thyroid volume measurement planes

**Source:** Authors' archive

### Definition of Goiter

Goiter was operationally defined as thyroid volume (TV) exceeding established normative ranges:

- Adults: TV > 10 mL (normal reference range: 7-10 mL)
- Pediatric patients: TV > 16.1 mL (normal reference range: 5.0-16.1 mL)

### Statistical Analysis

Data analysis was performed using PSPP (public domain statistical software). We employed:

- Pearson's correlation to assess MTLT-TTD relationships
- Linear regression (reporting  $R^2$  and  $\beta$ -coefficients)
- Receiver Operating Characteristic (ROC) curve analysis (reporting AUC, sensitivity, and specificity) to evaluate diagnostic accuracy for goiter, defined as: Adults: thyroid volume >10 mL and Children: >97th percentile for age.
- Statistical significance was defined a priori as  $p < 0.05$ .

## RESULTS

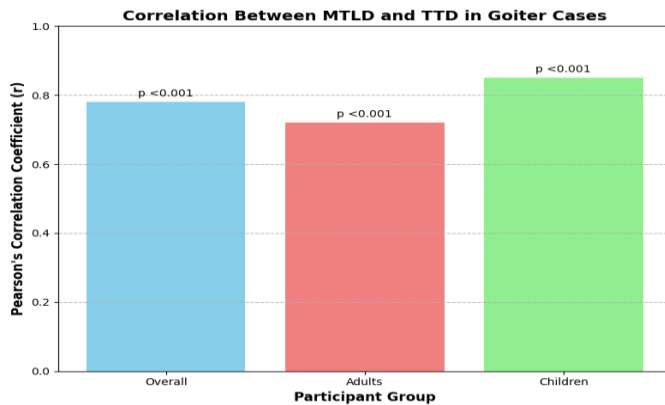
### Correlation Between MTLT and TTD in Goiter Detection

Ultrasound analysis of 300 thyroid images (200 adults; 100 children) revealed:

- A significant positive correlation between MTLT and TTD in goiter cases (Pearson's  $r=0.78$ ,  $p < 0.001$ ).
- This correlation persisted across age groups, with stronger associations in pediatric patients ( $r=0.85$ ) versus adults ( $r=0.72$ ), potentially reflecting developmental thyroid growth patterns (Graph 1).
- The MTLT:TTD ratio emerged as a significant anatomical predictor, particularly for diffuse goiter subtypes.

- Excellent interobserver agreement (ICC=0.92; 95% CI: 0.88-0.95)

**Graph 1.** Correlation between MTLT and TTD in goiter detection



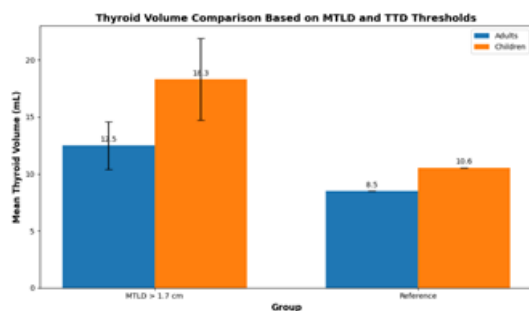
Source: Study results

### Threshold Values for Thyroid Volume Elevation

Subjects with MTLT exceeding normative TTD thresholds (>1.7 cm in adults, >2.4 cm in children) demonstrated significantly elevated thyroid volumes:

- Adults: 12.5 ± 2.1 mL (reference range: 7-10 mL)
- Children: 18.3 ± 3.6 mL (reference range: 5.0-16.1 mL) (p < 0.001) (Graph 2). These volumetric deviations confirmed goiter diagnosis according to ATA criteria<sup>(11)</sup> and established specific sonographic criteria based on relative thyroid and tracheal dimensions indicative of pathological thyroid enlargement.

**Graph 2.** Comparison of thyroid volumes in study population



Source: Study results

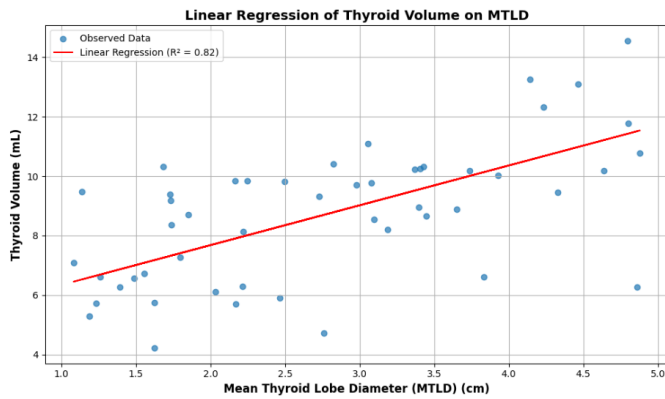
### Regression Analysis and Predictive Performance

Linear regression analysis demonstrated:

- Strong dependence of thyroid volume on MTLT ( $R^2 = 0.82$ ,  $\beta = 1.34$ ,  $p < 0.001$ ).
- Each 1 cm increase in MTLT predicted a 1.34 mL volume expansion.

- The MTLT/TTD relationship explained 82% of thyroid volume variance (Graph 3).
- The MTLT:TTD ratio showed superior diagnostic performance: Sensitivity: 89%, specificity: 93%, and Youden's index: 0.82

**Graph 3.** Regression analysis of thyroid volume prediction

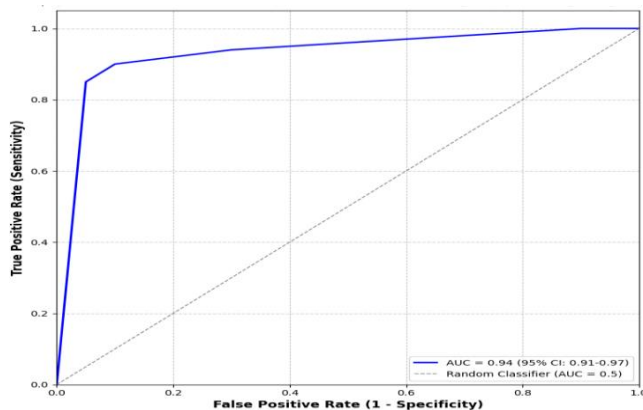


Source: Study results

### Diagnostic Accuracy of Tracheal Indices

Abnormal tracheal indices (1.7-2.4 cm versus observed mean  $2.6 \pm 0.3$  cm) significantly improved goiter detection accuracy. ROC curve analysis revealed: AUC = 0.94 (95% CI: 0.91-0.97), excellent discriminatory power (Graph 4). These findings suggest tracheal dimension alterations serve as valuable supplementary markers in the ultrasonographic assessment of thyroid enlargement.

**Graph 4.** ROC curve analysis of tracheal indices for goiter detection



Source: Study results

## DISCUSSION

Our findings demonstrate the diagnostic reliability of combined MTLT and TTD measurements for noninvasive ultrasonographic assessment of thyroid enlargement. The high diagnostic accuracy of this dual-parameter approach establishes its potential as a

valuable tool for sonographic goiter identification. These results support incorporating these combined measurements into routine ultrasonographic protocols to improve diagnostic confidence in detecting body surface area-adjusted thyroid volume increases.

The evaluation of thyroid lobe diameter and tracheal index has proven valuable for assessing thyroid-related conditions, particularly in detecting tracheal compression due to glandular enlargement. Studies demonstrate that measuring thyroid lobe diameter via imaging techniques (CT or ultrasound), combined with the tracheal index (thyroid-to-tracheal width ratio), provides crucial information about the mechanical impact of thyroid volume on airway patency<sup>(12)</sup>. These metrics effectively quantify goiter-induced tracheal narrowing, with research showing significant correlations between increased thyroid diameter and reduced tracheal cross-sectional area<sup>(13)</sup>. This interaction reflects a dynamic relationship where larger thyroid lobes exacerbate tracheal compression, as confirmed by volumetric studies<sup>(14)</sup>. Our evaluation of the MTLD:TTD ratio as a goiter predictor showed promising performance in distinguishing normal from enlarged thyroid volumes.

Accurate cervical anatomy assessment requires established normative data, which show considerable inter-individual variability<sup>(15)</sup>. Thyroid volume, primarily measured via ultrasonography, depends on factors including: age, sex, body surface area, iodine intake status. In iodine-sufficient populations, reference ranges are: adults: 7-10 mL, and children: 3-15 mL<sup>(16,17)</sup>. Similarly, tracheal transverse diameter (typically measured by CT or ultrasound) varies physiologically, correlating with sex and body habitus, with normal adult values ranging from 1.5 to 2.5 cm<sup>(18)</sup>. Precise clinical interpretation requires population-specific data, as geographic and nutritional factors may influence normative values. Our results revealed a significant positive correlation between tracheal diameter exceeding normative limits and increased thyroid volume in both adult and pediatric populations. This volumetric expansion consistently met current clinical guidelines for goiter diagnosis. Consequently, our study establishes specific sonographic criteria based on the tracheal-thyroid morphological relationship, independent of age and body surface area.

Our evaluation of thyroid ultrasound images across diverse age groups consistently revealed a significant positive correlation between the mean transverse diameter of thyroid lobes and tracheal width. This anatomical association suggests a fundamental physiological relationship that persists throughout different developmental stages.

We demonstrated that when the mean thyroid lobe diameter exceeds tracheal diameter, this parameter reliably indicates disproportionate thyroid volume expansion relative to: body surface area-adjusted standards, established age-related reference values. This dimensional comparison proves clinically applicable for both pediatric and adult populations, regardless of gender. The MTLD:TTD ratio effectively detects these morphological changes without requiring complex volumetric calculations, offering a practical clinical alternative.

While current guidelines recommend anatomical landmarks for thyroid assessment, incorporating tracheal metrics could improve diagnostic standardization<sup>(19,20)</sup>. Ultrasound evaluation of thyroid lobes relative to tracheal dimensions provides valuable anatomical context for assessing glandular enlargement, complementing conventional volume measurements.

## CONCLUSION

Our findings establish the thyrotracheal dimensional relationship as: an efficient predictor of thyroid volume, particularly valuable when traditional volumetry proves impractical, an effective method for goiter detection across diverse populations. The comparative evaluation of these adjacent structures during ultrasonography represents a reliable diagnostic approach for thyroid enlargement assessment.

**Competing Interests:** The authors declare no conflicts of interest relevant to this study.

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