

Pattern of Tc-99m Thyroid Scintigraphy in Different Thyroid Diseases:(Our Experience)

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ABSTRACT

Background: Thyrotoxicosis is a spectrum of disorders with a rather common clinical presentation with different aetiologies. It is essential to accurately diagnose the cause before starting treatment. Scintigraphy of thyroid helps in differentiating accurately the various causes.

Aim: This study aimed to evaluate the scintigraphic profile of thyrotoxicosis patients and to evaluate lobar activity differences in Technetium-99m (Tc-99m) thyroid scans among Egyptian patients with thyroid diseases, focusing on the influence of demographic factors (age and gender).

Patients and Methods: This was a retrospective cross-sectional study implemented at the Nuclear Medicine Unit at Sohag University in Egypt between January 2023 and June 2024 on 117 thyroid patients newly diagnosed for thyrotoxicosis.

Results: Most of patients (64.1%) were females, with a mean age of 40.6 ± 10.8 years. Thyroid stimulating hormone (TSH) levels were uniformly low (median (IQR: 0.01 (0.017)), supporting hyperthyroidism in the population. Thyroid uptake (TTU = Total Thyroid Uptake, LLU = Left lobe Uptake, RLU = Right lobe Uptake) peaked in the 36–45 age group and declined in individuals over 45. Males consistently showed higher TTU ($13.6 \pm 9.8\%$), LLU ($6.4 \pm 4.7\%$), and RLU ($7.1 \pm 5.1\%$) than females, with P-values < 0.001 . Lobar uptake patterns revealed a dominance of higher RLU across all TTU categories.

Conclusion: Using Tc 99m scintigraphy is a useful technique to differentiate between different a etiologies of thyrotoxicosis, with estimation of thyroid uptake.

Keywords: Technetium-99m pertechnetate; Thyroid; Thyroid scintigraph; Lobar difference.

INTRODUCTION

A prevalent illness that primarily affects women is thyrotoxicosis. Toxic multinodular goiter, toxic adenoma, and excessive thyroid hormone production, as in Graves' disease, are common causes of thyrotoxicosis. An essential self-limiting differential diagnosis is transient thyrotoxicosis, which is caused by an overabundance of thyroid hormone released from an inflamed thyroid gland as a result of thyroiditis. In the majority of instances, thyroid function tests (serum thyroid-stimulating hormone, thyroxine [T4], and triiodothyronine [T3]) combined with thyroid antibody serology aid in identifying the reason. Nuclear scanning, however, is probably required for the majority of patients in order to more precisely identify the reason and direct therapy choices. Thyroid scintigraphy plays an important role in determining various causes of clinical and subclinical thyrotoxicosis by measuring the functional status of the gland^[1].

Because of its low cost, ready availability, rapid single-visit imaging, lower radiation burden on the patient, and good image quality, ^{99m} Technetium (^{99m} Tc) pertechnetate is used in thyroid uptake evaluation. A thyroid scan with uptake utilizing technetium-99m (Tc-99m) pertechnetate is a standard component of thyroid nuclear imaging^[2,3].

Thyroid uptake, a quantitative indicator of thyroid function, is frequently included in addition to pictures. The proportion of the radioactive dose that is lodged in

the thyroid gland at the normal rate is known as thyroid uptake. When treating the causes of hyperthyroidism, this information is helpful in choosing the course of treatment and the appropriate dosage of I131^[3,4].

Due to several benefits, Tc-99m pertechnetate is widely used worldwide: (1) a brief half-life of 6 hours; (2) brief preservation in the gland; (3) lack of beta-radiation; (4) beneficial dosage of radiation to the thyroid gland (10,000 times lower than that of I-131) and to the entire body; (5) its 140 keV basic gamma photon is suitable for alignment using scintillation sensors; (6) it is generator produced, making it affordable; and (7) it is easily accessible from Molybdenum-Technetium generator^[5]. Despite the fact that the thyroid gland simply traps Tc-99m pertechnetate and does not organize it, in most cases, the imaging and uptake data offer all the information required for a precise clinical diagnosis^[6].

Thyroid diseases are among the most common endocrine disorders, significantly impacting patients' metabolic, cardiovascular, and overall health. Tc-99m thyroid scans are a vital diagnostic tool for evaluating thyroid function, particularly in detecting lobar asymmetry and quantifying uptake patterns. However, regional differences in thyroid disease prevalence, presentation, and uptake activity remain underexplored, especially in Egyptian populations^[2]. Understanding lobar variations in Tc-99m uptake and their relationship to demographic factors such as age and gender is critical

for improving diagnostic accuracy and tailoring treatment strategies. This study aimed to bridge this gap by analyzing Tc-99m thyroid scans in Egyptian patients with thyroid diseases, providing insights into the unique patterns of thyroid activity in this population. This study also aimed to evaluate lobar activity differences in Tc-99m thyroid scans among Egyptian patients with thyroid diseases, focusing on the influence of demographic factors (age and gender) and assessing the clinical implications for diagnosis and management.

PATIENTS AND METHODS

Study design and patients:

This retrospective cross-sectional study was implemented at the Nuclear Medicine Unit at Sohag University in Egypt between January 2023 and June 2024. Newly diagnosed thyrotoxicosis attending for thyroid scintigraphy were included except those with prior thyroid disease or surgery.

Laboratory findings:

Serum measures of thyroid stimulating hormone (TSH), free triiodothyronine (T3), and free thyroxine (T4) were used to get the laboratory evaluation of thyroid function. Uptake results of total thyroid, left lobe, and right lobe (%) were also recorded and compared.

Technetium 99 Scintigraphy:

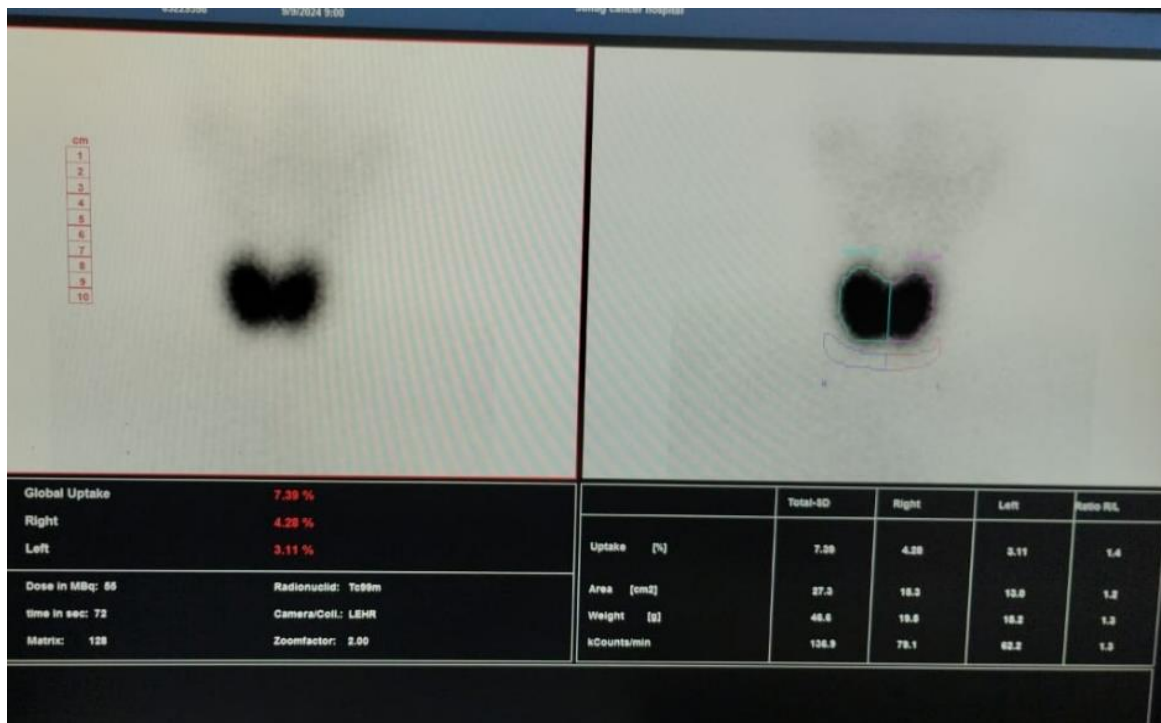
Patients were advised to fast for at least 2-4 hours before the procedure to enhance Technetium-99m

pertechnetate uptake in the thyroid. Medications that may interfere with thyroid function or uptake (e.g., thyroid hormone replacements, antithyroid drugs, iodine-containing substances) were reviewed and discontinued, if necessary, based on clinical judgment. The patients were positioned comfortably, typically lying on their back, with the neck slightly extended to expose the thyroid region.

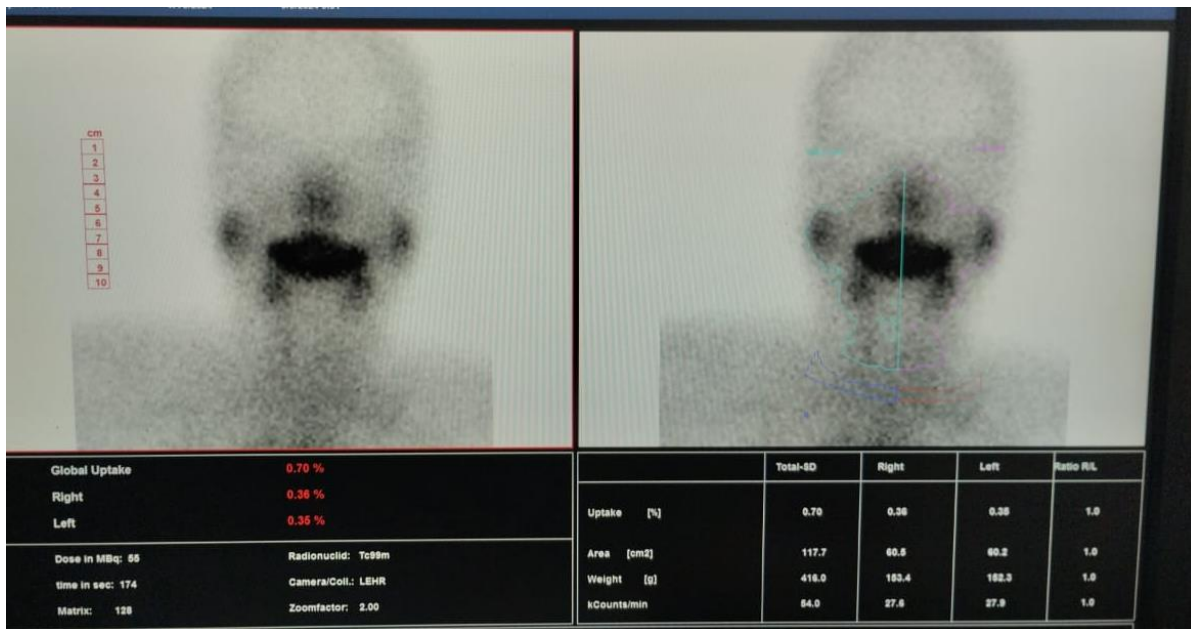
A dose of Technetium-99m pertechnetate was prepared (usually 3–5 mCi {111-185 MBq}), depending on institutional protocols and patient size. The dose was given through an intravenous injection, making sure to use the correct technique to prevent any leakage of the substance into surrounding tissues. Imaging was done 20 minutes after technetium 99m injection.

A GE gamma camera equipped with parallel-hole collimator at Sohag Cancer Institute was used for imaging. Static images were acquired of the anterior neck region to capture the distribution of the radiotracer in the thyroid. The technician ensured that both thyroid lobes are fully visualized within the field of view. Multiple views might be taken to assess symmetry and uptake distribution.

Regions of interest were manually or semi-automatically outlined for the right and left thyroid lobes. Background areas were defined to adjust for non-thyroidal uptake, normal thyroid uptake (0.5-4.5%) (**Figure 1**).



(A): Female patient 41 years old, thyroid scan shows intense radiotracer uptake at both thyroid lobes, total uptake 7.39, right thyroid lobe 4.28 uptake, left thyroid lobe uptake 3.11.



(B) Female patient 37 years old, thyroid scan shows low total uptake 0.78, right lobe uptake 0.39, left lobe uptake 0.39.

(Figure 1): Thyroid scan using Technetium-99m pertechnetate to evaluate thyroid function and morphology.

Ethical consent: The Academic and Ethical Committee, Sohag University approved the study. This work has been carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

The software program SPSS (v. 27) (IBM Corp.) was used for statistical analysis. The Mann-Whitney U test and Kruskal-Wallis test were used for statistical analysis due to the non-parametric nature of the data. The Mann-Whitney U test was applied to compare two independent groups when normality assumptions were not met, assessing differences in the distribution of the dependent variable. Meanwhile, the Kruskal-Wallis test, an extension of the Mann-Whitney U test, was employed to compare more than two independent groups, determining whether significant differences existed among them. Both tests provided robust analyses without assuming normal distribution, ensuring the validity of the results.

RESULTS

This study included a total of 117 thyroid patients and 64.1% were females, (38.5%) aged 36-45 years and 28.2% aged >45 years. Mean age was 40.6±10.8 years (Table 1).

Table (1): Patients' characteristics (n=117).

Parameter		Frequency (%)
Gender	Male	42 (35.9%)
	Female	75 (64.1%)
Age, y	18-25 years	9 (7.7%)
	26-35 years	30 (25.6%)
	36-45 years	45 (38.5%)
	>45 years	33 (28.2%)
Mean age (Min-Max)		40.6±10.8 (18-70)

Most cases (66.7%) were diagnosed with Graves' disease, followed by 17.9% who were within normal uptake (Figure 2).

Thyroid scan results

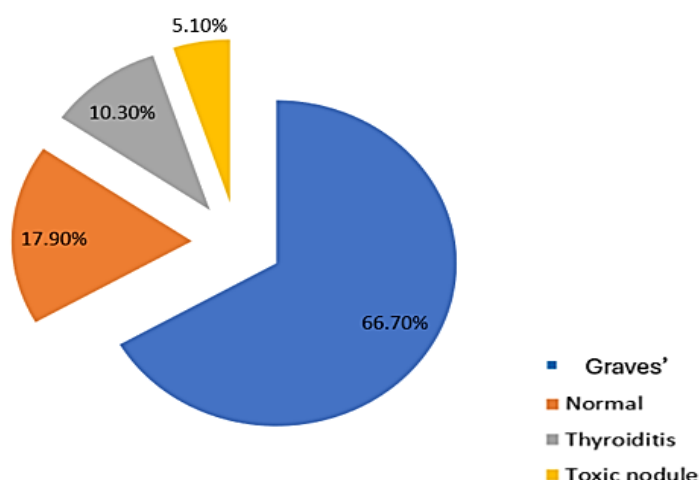


Figure (2): Thyroid scan results (n=117)

Notably, the median TSH (Thyroid Stimulating Hormone) level at 0.01 μ IU/mL is considerably below the reference range of 0.75-5.2 μ IU/mL, suggesting a potential prevalence of suppressed TSH, indicative of hyperthyroidism or external thyroid hormone use. Similarly, the median levels of Free T3 and Free T4 are above their respective reference ranges, with Free T3 at 4.9 pg/mL against a normal of 1.8-4.6 pg/mL, and Free T4 at 3.2 ng/mL against a normal of 0.93-1.79 ng/mL (Table 2).

Table (2): Laboratory thyroid results (n=117).

Parameter	Median (IQR)	Reference range
TSH (μ IU/mL)	0.01 (0.017)	0.75-5.2
Free T3 (pg/mL)	4.9 (3)	1.8-4.6
Free T4 (ng/mL)	3.2 (2.8)	0.93-1.79

TSH: Thyroid Stimulating Hormone, Free T3: Free Triiodothyronine, Free T4: Free Thyroxine (μ IU/mL) (pg/mL) (ng/mL)

There was a statistically significant difference in average age between males and females. Thyroiditis was more common in older age groups. There were no statistically significant differences in average age across the diagnostic categories (Table 3).

Table (3): Association between gender, thyroid scan results, and age parameters.

Parameter		Total	Mean age rank	P-value
Gender	Male	42	70.6	0.006*
	Female	75	52.2	
Thyroid scan results	Graves'	78	57.5	0.864**
	Normal	21	59.6	
	Thyroiditis	12	66.1	
	Toxic nodule	6	62	

*Mann-Whitney test

** Kruskal-Wallis test

TSH levels are nearly identical between males (58.6) and females (59.2), with a non-significant P-value of 0.915, indicating no gender-based variation. In contrast, Free T3 levels are markedly higher in males (72.9) compared to females (51.2), with a highly significant P-value (<0.001), suggesting that males exhibit greater thyroid activity in this parameter. Free T4 levels also appear higher in males (67.04) than females (54.5); however, the P-value (0.055) is borderline non-significant, indicating a possible trend that may require further investigation (Table 4).

Table (4): Association between the mean rank of laboratory thyroid results and patients' gender.

	Males (42)	Females (75)	P-value
TSH (uIU/mL)	58.6	59.2	0.915
Free T3 (pg/mL)	72.9	51.2	<0.001
Free T4 (ng/mL)	67.04	54.5	0.055

*Mann-Whitney test

TSH: Thyroid Stimulating Hormone, Free T3: Free Triiodothyronine, Free T4: Free Thyroxine

Males consistently exhibited higher mean ranks across all thyroid scan parameters compared to females, with statistically significant differences (p-values: 0.005, 0.003, 0.01), suggesting potential gender-related variations in thyroid function or scan uptake. Additionally, age appeared to influence scan outcomes, as individuals aged 36-45 demonstrated the highest mean ranks, whereas the 26-35 age group showed the lowest. These differences were also statistically significant (p-values: 0.031, 0.03, 0.039), pointing to the relevance of age in thyroid scan measurements (**Table 5**).

Table (5): Association between thyroid scan results and patients' sociodemographics.

Parameter		Mean rank			
		Total	TTU	LLU	RLU
Gender	Males	42	70.7	71.3	69.8
	Females	75	52.5	52.1	52.9
P-value*			0.005	0.003	0.01
Age	18-25	9	57	55.5	54
	26-35	30	44.7	44.6	46.4
	36-45	45	68.5	68.3	69.1
	>45	33	59.6	60.4	58.1
P-value**			0.031	0.03	0.039

TTU: Total Thyroid Uptake, LLU: Left Lobe Uptake, RLU: Right Lobe Uptake

*Mann-Whitney test

** Kruskal-Wallis test

This bar chart visually represents the mean rank differences in thyroid scan results (TTU, LLU, and RLU) between males and females. Across all parameters, males consistently show higher values (TTU: 70.7, LLU: 71.3, RLU: 69.8) compared to females (TTU: 52.5, LLU: 52.1, RLU: 52.9) (**Figure 4**).

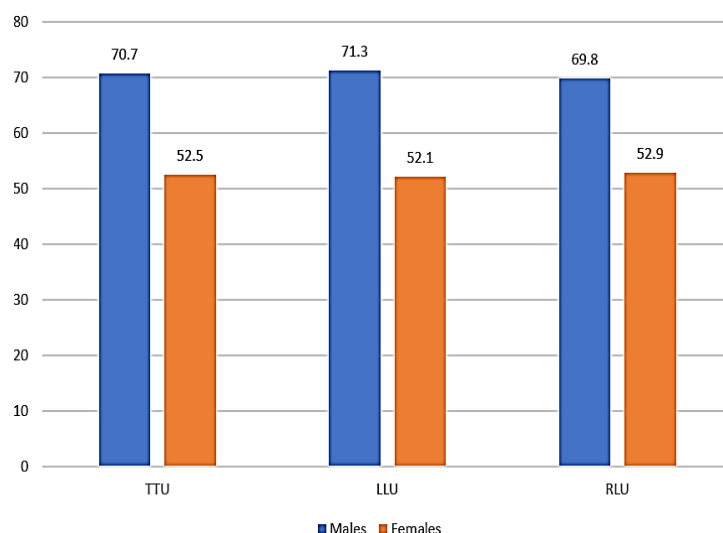


Figure (4): Gender-Based Differences in Measurements Across TTU, LLU, and RLU.

DISCUSSION

Numerous radiotracers are currently in use worldwide based on their accessibility and indications of the scan and uptake, according to the literature currently available on thyroid scintigraphy and uptake. Because the results of the uptake can be obtained in less than an hour at a single visit, Tc-99m pertechnetate is becoming the preferred radiotracer for patients with thyrotoxicosis [7,8].

There are significant gender differences, with females having a statistically lower average age than males in this study (P = 0.006). **Calcaterra et al.** reported that during puberty, females are more likely to acquire autoimmune thyroid illnesses, specifically early-stage Hashimoto's disease and late-stage Graves' disease. Males and females experience puberty in the same ways, which suggests that elements other than sex hormones play a part [7].

Free T3 levels are markedly higher in males (72.9) compared to females (51.2), with a highly significant P-value (<0.001). This is consistent with findings by **Calcaterra et al.**, which noted that females tend to have a tighter regulation of thyroid hormone levels due to hormonal and autoimmune factors [7]. The greater variability in males may reflect differences in physiological or metabolic demands, as suggested by **Liu et al.** [8].

TTU, RLU, and LLU were higher among males compared to females (P=0.005, P=0.003, and P=0.01), respectively. Our findings show a clear trend: thyroid uptake increases significantly with age, especially after 35 years. This is in line with the natural changes that happen in the body as we get older, like a decrease in thyroid reserve and a higher risk of thyroid problems such as nodular goiter and autoimmune thyroiditis (P=0.031). The greater uptake in older groups (>36 years) could also

suggest that there are compensatory processes at work for less-than-ideal thyroid function or undiagnosed subclinical thyroid issues. **Alshahrani *et al.*** also found that the intake of Tc-99m pertechnetate varies with age, since it declined with increasing age. Determining the typical values for Tc-99m pertechnetate uptake is crucial since this diagnostic test is frequently used to examine patients who may have thyrotoxicosis. Since the test's accuracy directs the diagnosis and treatment of thyrotoxicosis patients, it has significant clinical practice implications [9].

Paudel and Bhattarai also found that uptake trended upward as age increased. These findings emphasize how crucial it is to regularly assess and restore normal thyroid uptake reference values of Tc-99m pertechnetate in the population [10]. In contrast, earlier research stated that age and 99mTc-pertechnetate absorption were found to be negatively correlated [11, 12].

In this study, thyroid uptake was lowest in younger age groups (18–35 years) and peaked in the 36–45 age range, reflecting greater thyroid activity, before declining in those over 45 years, suggesting reduced thyroid function with aging. All uptake parameters (TTU, LLU, RLU) showed significant differences between age groups, with P-values <0.01, highlighting statistically significant age-related variations in thyroid activity. **Wagieh *et al.*** also found that younger patients (less than 40 years old) exhibited substantially higher TTU numbers than older patients [13]. 73.3% of patients younger than 40 had a total uptake level more than 20%, compared to 26.7% of older patients alone. Additionally, every woman in the young age group had a TTU level greater than 30% [14].

We found that higher RLU consistently dominated in all categories of TTU, especially at higher uptakes. Females tend to have a somewhat higher incidence of LLU and ELU in lower categories of TTU; however, these patterns grow less common as the level of TTU increases. In general, ELU is so rare in all categories as to underscore a strong lobar asymmetry in thyroid uptake patterns, irrespective of TTU levels. These results are in line with normal thyroid physiology and may be useful in diagnostic and therapeutic applications.

Strengths

One of the key strengths of this study is its comprehensive analysis of thyroid uptake across a wide range of age groups, enabling a detailed understanding of how thyroid function evolves over time. The use of quantitative measures ensures objective and reliable data to support clinical interpretations. Additionally, the statistical rigor, with the inclusion of significance testing (P-value), reinforces the credibility of the results, ensuring that observed differences are meaningful. Furthermore, the study's findings are directly relevant to clinical practice, offering valuable data that can guide the establishment of

population-specific reference values for thyroid diagnostics.

LIMITATIONS

Despite its strengths, this study has some limitations. The sample size, although robust at 117 patients, may limit the generalizability of the findings to larger or more diverse populations. Furthermore, the study is geographically specific, focusing on a single population, which may not account for variations in iodine intake or thyroid disease prevalence in other regions. Another limitation is the lack of consideration for additional variables such as iodine sufficiency, underlying thyroid pathologies, or comorbid conditions, which could significantly influence thyroid uptake levels. Finally, while the study includes both genders, the gender distribution across age groups may affect the generalizability of the findings, particularly if one gender is underrepresented in specific age categories. **Manthri *et al.*** also identified thyroid lobe differences in patients with unilateral graves' disease. According to their findings, this lobar difference may be caused by the distinct sensitivity of the left and right thyroid lobes to TSH stimulation, which appears to be present in healthy thyroid tissue devoid of any thyroid gland pathological processes [14].

CONCLUSION

The analysis of TTU thus shows significant gender- and age-based variations in thyroid activity that could provide valuable insights into physiological differences and possible clinical implications. Females consistently show higher proportions in categories such as "Higher RLU" across TTU levels, particularly in the TTU 20%-30% category. This suggests that females may have a predisposition toward higher lobar uptake in specific regions compared to males. Similarly, thyroid uptake patterns vary significantly with age, peaking in individuals aged 36–45 years, reflecting increased thyroid activity in this group, followed by a decline in those over 45 years, which suggests reduced thyroid function with aging. Lobar uptake patterns exhibit a clear dominance of higher RLU across all TTU categories, where right lobe dominance is almost universal. ELU is low in all categories, indicating marked lobar asymmetry in thyroid uptake.

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- **Conflict of Interest:** The author(s) had nothing to declare.

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