

# Ultrasound Assessment of Thyroid Nodules Using TIRADS and Its Association with Cytology Results: A Cross-Sectional Observational Study

Yenumula Praveen Raja<sup>1</sup>

<sup>1</sup>Assistant Professor, Department of Radiodiagnosis, Tripura Santiniketan Medical College, West Tripura, Tripura, India

## Abstract

**Background:** Thyroid nodules are common diseases both in clinical and radiologic practice and most are non-cancerous. Thyroid Imaging Reporting and Data System (TI-RADS) is a grading system that helps to stratify the malignancy risk and assists in choosing a nodule for fine-needle aspiration cytology. The objective is to evaluate thyroid nodules by ultrasound-based TI-RADS, and to investigate its association with cytological results. **Material and Methods:** It was a cross-sectional observational study that involved 50 thyroid nodule patients who underwent evaluation in the department of Surgery at Tripura Santiniketan Medical College, West Tripura, Tripura, India between the period August, 2024 – January, 2025. High-resolution ultrasonography of the thyroid was performed in all patients. The nodules were classified by the composition, echogenicity, margins, and shape, along with the presence or absence of echogenic foci, to TI-RADS. The Bethesda system was used to classify the FNA specimens. An appropriate statistical test was used to evaluate the association between the results of the cytology and the TI-RADS category. **Results:** The average age of the population studied was  $42.6 \pm 12.8$  years, with 72.0% of the cases being female. Solitary thyroid nodules were found in 68.0%. The highest percentage were found to have been in the category TR4, followed by TR3 and TR5. The cytology diagnostics showed benign findings in 68.0%, indeterminate findings in 14.0%, suspicious cytology in 6.0% and malignant cytology in 12.0%. The 2 positive outcomes of cytology (suspicious and malignant cytology) correlated with the higher TRADS categories and were most frequently seen with nodules assigned to a TR5 category. Statistically, there was a correlation between the cytology category and TI-RADS category. **Conclusion:** There was a significant correlation between Ultrasound based TI-RADS and cytology result, and the Ultrasound-based TI-RADS was useful for risk stratification of thyroid nodules. Excellent correlation of higher TI-RADS was found with suspicious or malignant cytology results.

**Keywords:** From the thyroid standpoint, keywords are thyroid nodule, TI-RADS, ultrasonography and fine-needle aspiration cytology, Bethesda system and thyroid malignancy.

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## INTRODUCTION

Thyroid nodules are tumor-like areas of the thyroid gland which differ in appearance from the rest of the thyroid tissue on a radiological exam. They are readily detected, thanks to the growing use of neck ultrasonography and cross-sectional imaging. The epidemiological data leads to the view that women, older people, iodine deficient areas and radiation exposed people have a higher frequency of thyroid nodules.<sup>[1]</sup> Most nodules are asymptomatic and clinically indolent, but it is the task of the diagnostician to determine the smaller group that may be clinically significant – either because they contain thyroid malignancy or because they need active treatment.<sup>[2]</sup>

The non-invasive, readily available, inexpensive, and high spatial resolution of ultrasonography make it the first-line imaging modality for thyroid nodules. The ultrasound features that increase the likelihood of malignancy are solid composition, prominent hypoechogenicity, irregular or lobulated margins, taller-than-wide shape, and punctate echogenic foci.<sup>[3,4]</sup> Interpretation of ultrasound features is still variable, however, and no single feature has an

acceptable degree of diagnostic accuracy in all clinical situations.<sup>[5]</sup> This restriction has pushed towards the utilization of structured reporting systems which relate different sonographic parameters to reproducible risk categories.

The Thyroid Imaging Reporting and Data System (TI-RADS) was created in order to standardize the reporting procedure of thyroid ultrasound and enhance the selection of nodules suitable for cytological evaluation. ACR TI-RADS assigns points to these ultrasound characteristics and categorize nodules from benign to highly suspicious, thus helping to make consistent decisions about follow-up and fine-needle aspiration.<sup>[6,7]</sup> Additionally,

**Address for correspondence:** Dr. Yenumula Praveen Raja, Assistant Professor, Department of Radiodiagnosis, Tripura Santiniketan Medical College, West Tripura, Tripura, India. E-mail: [praveenraj.aiims@gmail.com](mailto:praveenraj.aiims@gmail.com)

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other risk-stratification systems, such as the previous TI-RADS system, EU-TIRADS, Korean consensus systems, etc., have highlighted the importance of using risk-based recommendations for biopsy combined with the nodule morphology.<sup>[8-11]</sup>

FNA cytology is still a valuable biopsy tool for the diagnosis of clinically and radiographically selected thyroid nodules. The Bethesda System for Reporting Thyroid Cytopathology offers a 6-tiered reporting system that correlates cytologic findings with the estimated malignancy risk and clinical management.<sup>[12,13]</sup> To enhance the local diagnostic pathways, there could be good correlations between the categories of the ultrasound and those of the Bethesda cytology: there could be more suspicious or malignant cytology in a given ultrasonographic category.

The aims of the present study were to evaluate thyroid nodules by ultrasound based TI-RADS classification and to see its relationship with cytology results of the patients who visited Tripura Santiniketan Medical College, West Tripura, Tripura, India. The aim of the study was also to describe the demographic profile, sonographic characteristics, distribution of TI-RADS, Bethesda cytology pattern, and the trend of cytologic abnormality in the various categories of TI-RADS. This is because institutional-level diagnostics thresholds, referral procedures and access to cytology services are diverse locally.

## MATERIALS AND METHODS

**Study design and setting:** This cross-sectional observational study was conducted in the Department of Radiodiagnosis in collaboration with the clinical departments involved in thyroid nodule evaluation at Tripura Santiniketan Medical College, West Tripura, Tripura, India. The study period was from August 2024 to January 2025. Patients with clinically suspected or previously detected thyroid nodules who underwent ultrasound assessment and fine-needle aspiration cytology were included after eligibility screening.

**Study population:** A total of 50 patients were included using consecutive sampling. Patients of either sex with one or more thyroid nodules detected on clinical examination or ultrasound were eligible. In patients with multinodular goitre, the dominant nodule or the most suspicious nodule on ultrasound was selected for analysis. Patients with prior thyroid surgery, previously treated thyroid malignancy, diffuse thyroiditis without a measurable nodule, inadequate clinical records, or unavailable cytology findings were excluded.

**Ultrasound assessment:** High-resolution ultrasound examination of the thyroid gland was performed using a high-frequency linear transducer. The laterality, size, composition, echogenicity, margin, shape of each nodule were evaluated. Laterality, size, composition, echogenicity, margin, shape of each nodule were evaluated. Nodules were classified as cystic or spongiform, mixed solid-cystic, or solid/predominantly solid. The echogenicity was classified as anechoic/isoechoic, hypoechoic or very hypoechoic. According to the known descriptors of the TI-RADS, the margins, shape and echogenic foci were captured. Nodules were categorised as TI-RADS using a structured approach as outlined in the ACR TI-RADS and thyroid ultrasound reporting literature.<sup>[4,6,7,10,11]</sup>

**Cytology assessment:** Fine-needle aspiration cytology was performed on the nodules indicated by clinical and ultrasound examination with regards to risk profile. The Bethesda System for Reporting Thyroid Cytopathology (BSR-TC) was used to evaluate cytology smears and report the findings. The categories for analysis were: Bethesda II, benign; Bethesda III, atypia of undetermined significance/follicular lesion of undetermined significance; Bethesda IV, follicular neoplasm/suspicious for follicular neoplasm; Bethesda V, suspicious for malignancy; and Bethesda VI, malignant.<sup>[12,13]</sup>

**Statistical analysis:** The data was entered to a spreadsheet and analyzed by descriptive and inferential statistics. For continuous variables the mean and standard deviation were calculated. The categorical variables were presented as frequency and percentage. The correlation of cytology result, and the TI-RADS category was carried out with Chi-square test. A p-value less than 0.05 was considered statistically significant.

**Ethical considerations:** The study was conducted in accordance with institutional ethical standards and the principles of the Declaration of Helsinki. Patient confidentiality was maintained during data collection, analysis. Institutional ethics approval was obtained from Tripura Santiniketan Medical College, West Tripura, Tripura, India, and informed consent was obtained as applicable for ultrasound-guided cytological evaluation.

## RESULTS

A total of 50 patients with thyroid nodules were included in the study. The mean age was  $42.6 \pm 12.8$  years, with most patients belonging to the 31-50 years age group. Females constituted 72.0% of the study population. Solitary thyroid nodules were observed in 68.0% of cases, while 32.0% had a dominant nodule in multinodular goitre. Right-lobe involvement was more common than left-lobe and isthmic involvement. The baseline demographic and clinical profile is shown in [Table 1].

**Table 1: Baseline demographic and clinical profile of the study population**

Variable	Category / Value	Frequency / Mean	Percentage / SD
Total sample size	—	50	100.0
Age, years	Mean $\pm$ SD	42.6	$\pm 12.8$
Age group	$\leq 30$ years	8	16.0
	31-40 years	15	30.0
	41-50 years	14	28.0
	$> 50$ years	13	26.0
Sex	Male	14	28.0
	Female	36	72.0
Type of nodule	Solitary thyroid nodule	34	68.0
	Dominant nodule in multinodular goitre	16	32.0

Laterality	Right lobe	26	52.0
	Left lobe	20	40.0
Nodule size, cm	Isthmus	4	8.0
	Mean ± SD	2.3	±0.9

On ultrasound examination, solid or predominantly solid nodules were identified in 44.0% of patients, while mixed solid-cystic nodules were also seen in 44.0%. Hypoechoic and very hypoechoic nodules together accounted for 52.0% of cases. Suspicious features such as irregular or lobulated

margins, taller-than-wide shape, and punctate echogenic foci were observed in 24.0%, 12.0%, and 16.0% of patients, respectively. These ultrasound characteristics are presented in [Table 2].

**Table 2: Ultrasound characteristics of thyroid nodules**

Ultrasound feature	Category	Frequency	Percentage
Composition	Cystic/spongiform	6	12.0
	Mixed solid-cystic	22	44.0
	Solid/predominantly solid	22	44.0
Echogenicity	Anechoic/isoechoic	24	48.0
	Hypoechoic	21	42.0
	Very hypoechoic	5	10.0
Margins	Smooth/ill-defined	38	76.0
	Irregular/lobulated	12	24.0
Shape	Wider-than-tall	44	88.0
	Taller-than-wide	6	12.0
Echogenic foci	Absent/comet-tail artefact	34	68.0
	Macrocalcification	8	16.0
	Punctate echogenic foci	8	16.0

According to TI-RADS classification, TR4 was the most common category, seen in 40.0% of patients, followed by TR3 in 32.0%. TR5 nodules were observed in 20.0% of cases. Cytology revealed benign findings in 68.0% of

patients, while suspicious or malignant cytology was observed in 18.0%. The distribution of nodules according to TI-RADS and Bethesda cytology categories is shown in [Table 3].

**Table 3: Distribution of nodules according to TI-RADS and cytology findings**

Variable	Category	Frequency	Percentage
TI-RADS category	TR2	4	8.0
	TR3	16	32.0
	TR4	20	40.0
	TR5	10	20.0
Cytology category	Bethesda II: Benign	34	68.0
	Bethesda III: AUS/FLUS	4	8.0
	Bethesda IV: Follicular neoplasm/suspicious for follicular neoplasm	3	6.0
	Bethesda V: Suspicious for malignancy	3	6.0
	Bethesda VI: Malignant	6	12.0

A progressive increase in cytological abnormality was observed with higher TI-RADS categories. All TR2 nodules were benign on cytology. Among TR3 nodules, 15 were benign and one showed atypia. In TR4 nodules, most cases were benign; however, Bethesda III, IV, and V categories

were also observed. TR5 nodules showed the highest association with malignancy, with 6 cases reported as Bethesda VI and 2 cases reported as Bethesda V. The association between TI-RADS category and cytology was statistically significant, as shown in [Table 4].

**Table 4: Association between TI-RADS category and cytology findings**

TI-RADS category	Bethesda II	Bethesda III	Bethesda IV	Bethesda V	Bethesda VI	Total
TR2	4	0	0	0	0	4
TR3	15	1	0	0	0	16
TR4	14	3	2	1	0	20
TR5	1	0	1	2	6	10
Total	34	4	3	3	6	50

Chi-square test:  $\chi^2 = 40.03$ ,  $p < 0.001$ .

Overall, higher TI-RADS categories showed greater association with suspicious and malignant cytology. TR5 nodules had the highest proportion of Bethesda V and VI findings, supporting the usefulness of ultrasound-based TI-RADS classification in risk stratification and selection of

nodules for cytological evaluation.

## DISCUSSION

The present cross-sectional observational study evaluated 50

patients with thyroid nodules using ultrasound-based TI-RADS and correlated the findings with cytology results. Male and female predominance was observed in the study population with females accounting for 72.0% of the cases. This is a typical finding of thyroid nodule epidemiology where thyroid nodular disease is more common in women, and with age.<sup>[1,2]</sup> The majority of patients in the present study were in the 31-50 year age group, suggesting that fallopian gland nodules are very common in the economically active adult age group and a clinically active patient population.

A total of 44.0% of cases were solid or predominantly solid on ultrasound and 52.0% had hypoechoic or very hypoechoic appearance. These features were less common overall but were clinically significant as they are part of existing ultrasound risk stratification approaches to thyroid malignancy,<sup>[4,6,7]</sup> irregular margins, taller than wide shape, and punctate echogenic foci. The accuracy of ultrasound is variable for each feature and composite systems as TI-RADS have been shown to have increased accuracy in previous systematic review evidence compared with individual ultrasound features which are determined by a given descriptor.<sup>[5]</sup>

In this study, TR4 was the most common category of TI-RADS followed by TR3 and TR5. The cytology profile was benign in 68.0% of patients, reaffirming the overall fact that the majority of thyroid nodules are benign and do not necessarily need aggressive therapy.<sup>[2,3]</sup> The indeterminate cytology group consisted of 14.0% and suspicious or malignant cytology was found in 18.0% of the samples. The Bethesda system is helpful in this respect for standardizing the terminology used in cytology and for enabling the clinician to correlate the cytological diagnosis with further investigation, repeat aspiration, molecular testing and surgery if necessary.<sup>[12,13]</sup>

The conclusion of this study was the statistically significant relationship between increase in TI-RADS category and cytological abnormality. Nodules were TR2 – all were benign – and TR3 – suspicious or malignant cytology were not present. On the other hand, there was a high burden of Bethesda VI and V cytology in the TR5 nodules. These results are consistent with the results of the literature presented in relation to the category of ultrasound that was published first and later used by TI-RAD literature, which showed the increasing risk of malignancy according to higher ultrasound categories.<sup>[8,9]</sup> EU-TIRADS and the Japanese thyroid ultrasound classification, adopted by Korea, also show similar characteristics: the high-suspicion morphology strongly determines the choice of biopsy and clinical prioritization.<sup>[10,11]</sup>

The present findings underscore the importance of structured reporting of thyroid ultrasound exams in the day-to-day clinical setting. TI-RADS enhances the communication among radiologists, clinicians and cytopathologists by translating the sonographic morphology into clinically important risk categories. In resource limited areas, this structured grading can be especially helpful in eliminating unnecessary aspirations of low-risk nodules, while providing timely cytologic evaluation of high-risk nodules. So, TI-RADS and Bethesda cytology work together to facilitate a

logical, sequential approach to evaluation of thyroid nodules.

#### **Limitations**

Only modest sample size from a single institution which does not allow for broad generalizability. Not all cytology categories were followed to final pathological diagnosis, and there was no follow-up for Bethesda III/IV nodules. No separate assessment of interobserver variability was performed with regard to ultrasound grading. Case distribution was influenced by referral patterns and operators' experience. Outcomes following follow up, molecular assays, and long-term clinical disease progression were not included in the analysis.

#### **CONCLUSION**

The present study was successful in showing that there is a significant correlation between ultrasound-based TIRADS and the cytology results in patients who present with thyroid nodules. Lower TI-RADS tended to have benign cytology, while the suspicious and malignant cytology were clustered in TR5 nodules. The findings validate the clinical utility, repeatability, and usefulness of TI-RADS in thyroid nodule risk stratification. In addition to the Bethesda cytology, TI-RADS can help to identify nodules that may require more detailed examination and help prevent unnecessary invasive interventions of low-risk nodules. To enhance the consistency of thyroid nodule diagnosis, accelerate the cytological assessment of high-risk thyroid nodules and support patient management and thyroid nodule care quality in clinical practice, structured ultrasound reporting should be established as part of thyroid nodule assessment.

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#### **Conflicts of interest**

There are no conflicts of interest.

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