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ORIGINAL RESEARCH ARTICLE



Decoding Thyroid Lesions – A Correlative Study Between Cytology and Radiological Findings

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Abstract

Background: Thyroid nodules are among the most frequently encountered endocrine lesions, with the majority being benign while a small but significant proportion harbor malignancy. Accurate preoperative risk stratification is essential to avoid unnecessary surgical intervention and ensure timely management of malignant lesions. Fine-needle aspiration cytology (FNAC) and ultrasonography are widely used diagnostic tools, and their combined application may enhance diagnostic accuracy.

Objectives: To correlate cytological findings categorized according to the Bethesda System for Reporting Thyroid Cytopathology with ultrasonographic findings classified using the ACR TI-RADS system and to evaluate their diagnostic performance against histopathological examination.

Materials and Methods: This cross-sectional observational study included 261 patients with thyroid lesions who underwent FNAC, ultrasonographic evaluation, and subsequent surgical excision between January 2023 and December 2024. Cytological diagnoses were reported according to the Bethesda System, while ultrasonographic findings were categorized using ACR TI-RADS. Histopathological examination served as the gold standard. Sensitivity, specificity, positive predictive value, negative predictive value, diagnostic accuracy, and agreement between modalities were assessed.

Results: Of the 261 patients studied, females constituted 80.1% of cases, with the highest frequency observed in the 21–40-year age group. Bethesda category II lesions were the most common cytological diagnosis (67.4%), while TI-RADS category TR3 represented the largest radiological group (30.3%). FNAC demonstrated a sensitivity of 86.0%, specificity of 91.5%, and diagnostic accuracy of 89.3%. Ultrasonography showed a sensitivity of 82.4%, specificity of 88.7%, and accuracy of 86.2%. The combined use of FNAC and TI-RADS significantly improved diagnostic performance, achieving a sensitivity of 92.9%, specificity of 94.1%, and overall accuracy of 93.4%. Discordant findings were predominantly encountered in indeterminate cytological categories.

Conclusion: Integration of Bethesda-based cytological reporting with ACR TI-RADS risk stratification substantially improves the preoperative evaluation of thyroid nodules. The combined approach enhances diagnostic accuracy, facilitates more effective risk stratification, and supports informed clinical decision-making, thereby reducing unnecessary surgical procedures while ensuring appropriate management of malignant thyroid lesions.

Key words: Thyroid nodules, Fineneedle aspiration cytology, Bethesda system, ACR TIRADS, Ultrasonography, Histopathology

1 | INTRODUCTION

Thyroid nodules are among the most common endocrine disorders encountered in clin-

ical practice, with their detection increasing substantially due to the widespread use of high-resolution ultrasonography and other imaging modalities. Although most thyroid nodules are

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benign, a small but clinically significant proportion represents malignant neoplasms requiring prompt diagnosis and appropriate management. Accurate preoperative differentiation between benign and malignant lesions is therefore essential to avoid unnecessary surgical intervention while ensuring timely treatment of thyroid malignancies. (1–3)

Fine-needle aspiration cytology (FNAC) is regarded as the primary diagnostic modality for the evaluation of thyroid nodules owing to its simplicity, safety, cost-effectiveness, and high diagnostic accuracy. (4, 5) The introduction of The Bethesda System for Reporting Thyroid Cytopathology (TBSRTC) has significantly improved standardization of thyroid cytology reporting by providing uniform diagnostic categories, associated risks of malignancy, and management recommendations. (6, 7) Despite its proven utility, FNAC has certain limitations, particularly in indeterminate categories such as atypia of undetermined significance (AUS/FLUS) and follicular neoplasms, where definitive distinction between benign and malignant lesions remains challenging. (8, 9)

Ultrasonography serves as an important complementary tool in the assessment of thyroid nodules by providing valuable information regarding nodule composition, echogenicity, margins, shape, and calcification patterns. (10, 11) To improve consistency in radiological interpretation and malignancy risk assessment, the American College of Radiology Thyroid Imaging Reporting and Data System (ACR TI-RADS) was developed as a standardized risk stratification system. (12) Increasing TI-RADS categories have been shown to correlate with progressively higher risks of malignancy and assist clinicians in identifying nodules that warrant FNAC or closer surveillance. (13, 14)

Several studies have demonstrated that integration of cytological findings with ultrasonographic risk stratification improves diagnostic confidence and enhances the preoperative evaluation of thyroid nodules. (15, 16) Correlation of FNAC findings and TI-RADS categorization with histopathological examination, which remains the gold standard for diagnosis, can provide valuable insights into the diagnostic strengths and limitations of these modalities and facilitate optimal patient management. (17, 18)

In view of the growing importance of standardized cytological and radiological reporting systems, the

present study was undertaken to correlate cytological findings categorized according to the Bethesda System with ultrasonographic findings classified using the ACR TI-RADS system and to evaluate their diagnostic performance against histopathological examination. The study also aimed to assess the utility of an integrated cyto-radiological approach in improving risk stratification and diagnostic accuracy in thyroid lesions. (19–23)

2 | MATERIALS AND METHODS

This hospital-based cross-sectional observational study was conducted in the Departments of Pathology and Radiology of a tertiary care teaching hospital from January 2023 to December 2024 after obtaining approval from the Institutional Ethics Committee. A total of 261 patients presenting with thyroid swellings who underwent ultrasonographic evaluation, fine-needle aspiration cytology (FNAC), and subsequent surgical excision were included in the study.

Patients with available cytological, radiological, and histopathological findings were included in the study. Cases with inadequate FNAC smears, incomplete records, or unavailable histopathological follow-up were excluded.

FNAC was performed using standard techniques under aseptic precautions. Air-dried smears were stained with May-Grünwald-Giemsa stain, while alcohol-fixed smears were stained using the Papanicolaou method. Cytological findings were categorized according to The Bethesda System for Reporting Thyroid Cytopathology (TBSRTC).

All patients underwent ultrasonographic examination of the thyroid gland. Sonographic features including composition, echogenicity, margins, shape, and calcifications were evaluated, and nodules were classified according to the American College of Radiology Thyroid Imaging Reporting and Data System (ACR TI-RADS).

All surgically excised thyroid specimens were processed routinely and stained with hematoxylin and eosin. Histopathological examination was considered the gold standard for the final diagnosis. Cytological and radiological findings were correlated

with histopathological results to assess the diagnostic performance of FNAC and ultrasonography in thyroid lesions.

Data were entered into Microsoft Excel and analyzed using SPSS software. For statistical analysis, indeterminate cytological categories were analyzed according to the predefined study criteria, while histopathological diagnosis was considered the reference standard. Sensitivity, specificity, positive predictive value, negative predictive value, diagnostic accuracy, and kappa agreement were calculated using histopathological diagnosis as the gold standard. A p-value of less than 0.05 was considered statistically significant.

3 | RESULTS

A total of 261 patients with thyroid lesions were included in the study. Females constituted the majority of cases (80.1%), while males accounted for 19.9%. The highest number of patients belonged to the 21–40 years age group (42.9%), followed by the 41–60 years age group (36.0%). Female predominance was observed across all age groups Table 1.

According to The Bethesda System for Reporting Thyroid Cytopathology, Bethesda Category II (Benign) was the most common cytological diagnosis, accounting for 67.4% of cases. Bethesda Categories III and IV constituted 10.7% and 8.4% of cases, respectively, while Bethesda Categories V and VI together accounted for 8.8% of cases. Non-diagnostic smears (Bethesda Category I) comprised 4.6% of the study population Table 2.

Ultrasonographic evaluation using the ACR TI-RADS classification revealed that TI-RADS category TR3 was the most frequently encountered category (30.3%), followed by TR4 (23.4%) and TR2 (22.2%). High-risk nodules classified as TR5 constituted 11.1% of cases Table 3.

Correlation of FNAC findings with histopathological examination demonstrated a high degree of concordance. Among cytologically benign lesions, the majority were confirmed as benign on histopathology, whereas most lesions categorized as suspicious

or malignant on cytology were subsequently proven malignant on histopathological examination. Discordant cases were predominantly observed in the indeterminate cytological categories Table 4.

The diagnostic performance of FNAC showed a sensitivity of 86.0%, specificity of 91.5%, and overall diagnostic accuracy of 89.3%. Ultrasonography demonstrated a sensitivity of 82.4%, specificity of 88.7%, and diagnostic accuracy of 86.2%. The combined application of FNAC and TI-RADS yielded the highest diagnostic performance, with a sensitivity of 92.9%, specificity of 94.1%, and overall accuracy of 93.4%, indicating the added value of an integrated cyto-radiological approach in the evaluation of thyroid lesions Table 5.

Table 1. Age and Sex Distribution of Patients with Thyroid Lesions (n = 261)

Age Group (years)	Male(%)	Female (%)	Total (%)
<20	4 (1.5)	14 (5.4)	18(6.9)
21–40	18 (6.9)	94 (36.0)	112 (42.9)
41–60	20 (7.7)	74 (28.3)	94 (36.0)
>60	10 (3.8)	27 (10.4)	37 (14.2)
Total	52 (19.9)	209 (80.1)	261 (100)

Table 2. Distribution of Thyroid Lesions According to Bethesda System

Bethesda Category		Diagnosis	Number (%)
I	Non-diagnostic	12	(4.6)
II	Benign	176	(67.4)
III	AUS / FLUS	28	(10.7)
IV	Follicular neoplasm	22	(8.4)
V	Suspicious for malignancy	11	(4.2)
VI	Malignant	12	(4.6)
Total		261	261(100)

Table 3. Distribution of Thyroid Lesions According to ACR TI-RADS

TI-RADS Category	Number (%)
TR1	34 (13.0)
TR2	58 (22.2)
TR3	79 (30.3)
TR4	61 (23.4)
TR5	29 (11.1)
Total	261 (100)

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Table 4. FNAC and Histopathology Correlation

FNAC Category	Benign on HPE	Malignant on HPE
Benign	168	8
Indeterminate	32	18
Suspicious/Malignant	4	31

Table 5. Diagnostic Performance of FNAC and Ultrasonography

Modality	Sensitivity (%)	Specificity (%)	Accuracy (%)
FNAC	86.0	91.5	89.3
USG (TI-RADS)	82.4	88.7	86.2
FNAC + USG	92.9	94.1	93.4

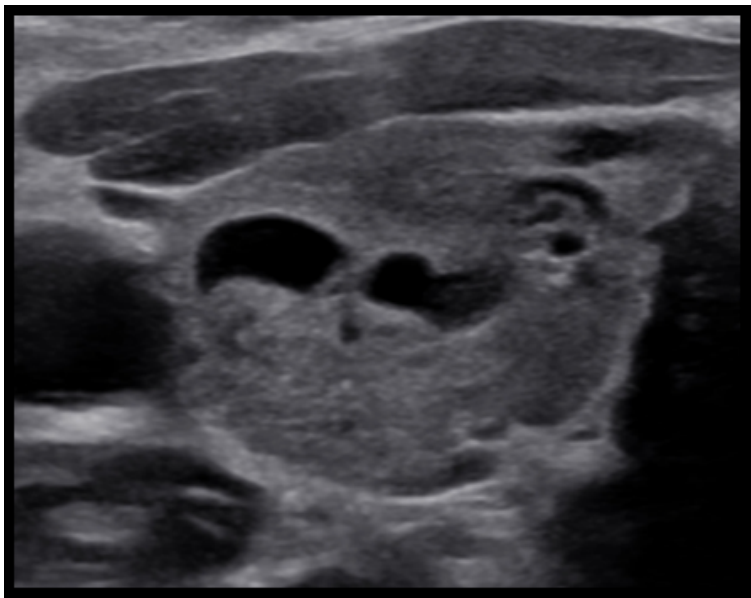


Fig. 1: USG- Multiple small colloid cysts of varying sizes in right lobe of thyroid- TIRADS-II

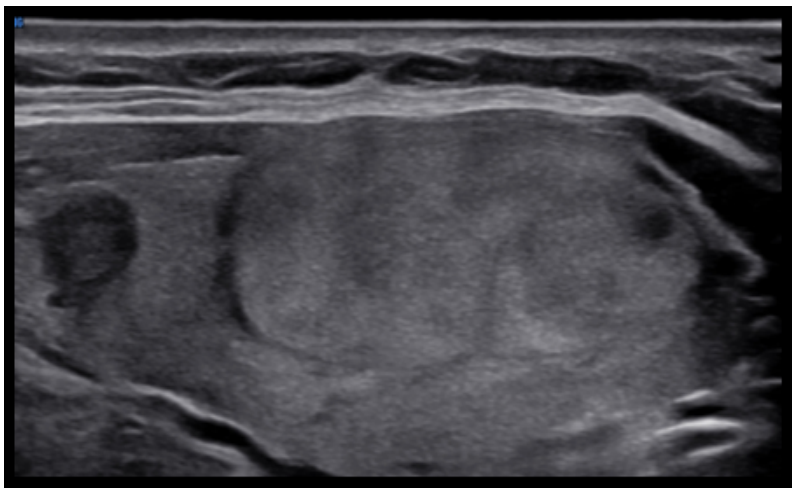


Fig. 2: USG- well defined hyperechoic lesion in rightlobe of thyroid- TIRADS-III

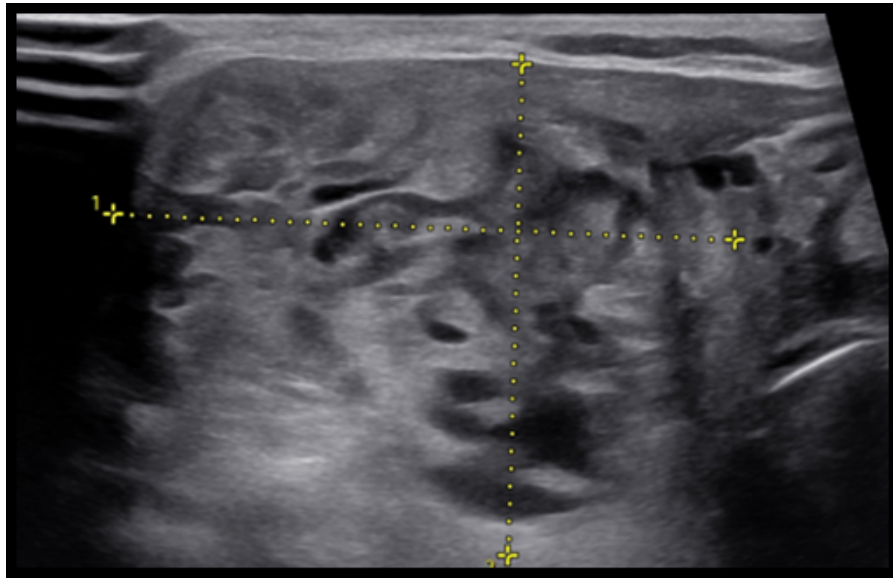


Fig. 3: USG- multiple well defined heteroechoic spongiform lesions with cystic space within & few internal echogenic calcific foci in left lobe of thyroid, suspicious of malignancy- TIRADS-IV

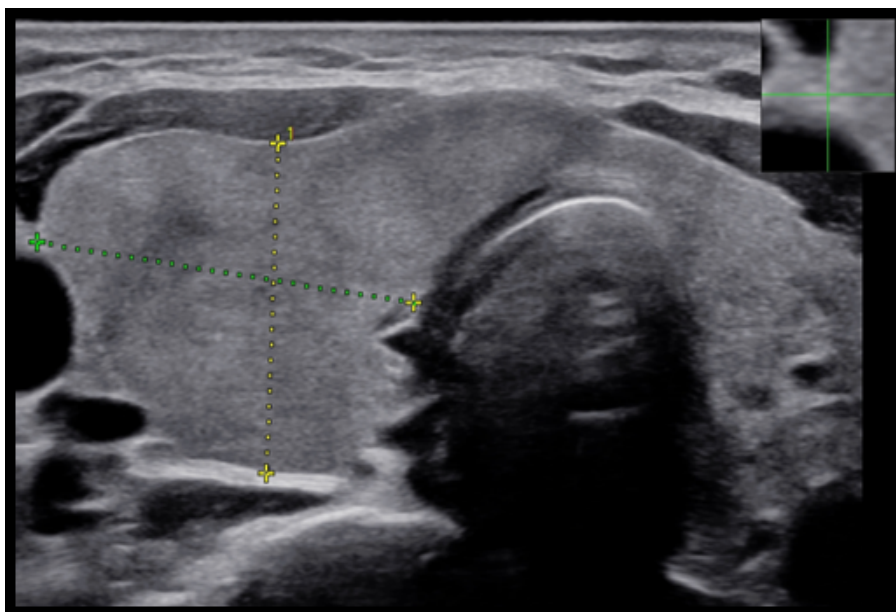


Fig. 4: USG- well defined taller than wider solid isohypoechoic nodule with few micro & macro calcifications in right lobe of thyroid.- TIRADS-V

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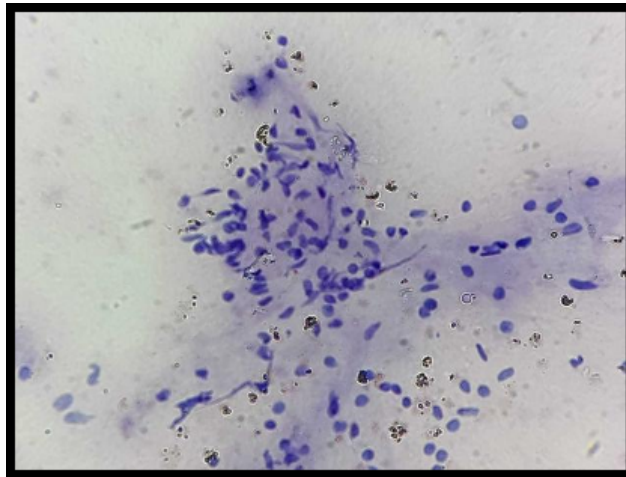


Fig. 5: 40X-Giemsa stain: Bethesda category- II: Benign: MULTINODULAR GOITRE: Moderately cellular FNAC smear shows loosely cohesive sheets of uniform follicular epithelial cells and scattered macrophages.

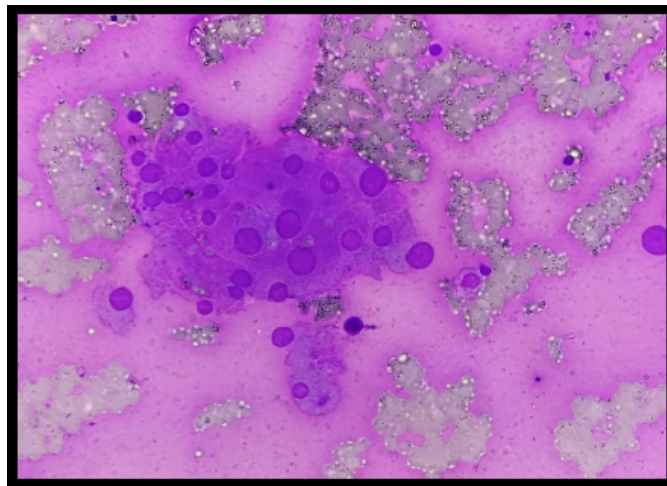


Fig. 6: 40X- Giemsa stain: Bethesda category-IV: Hurthle Cell Neoplasm: Moderately cellular FNAC smear show sheets & microfollicles of oncocytic/ hurthle cells with abundant granular cytoplasm and prominent nucleoli.

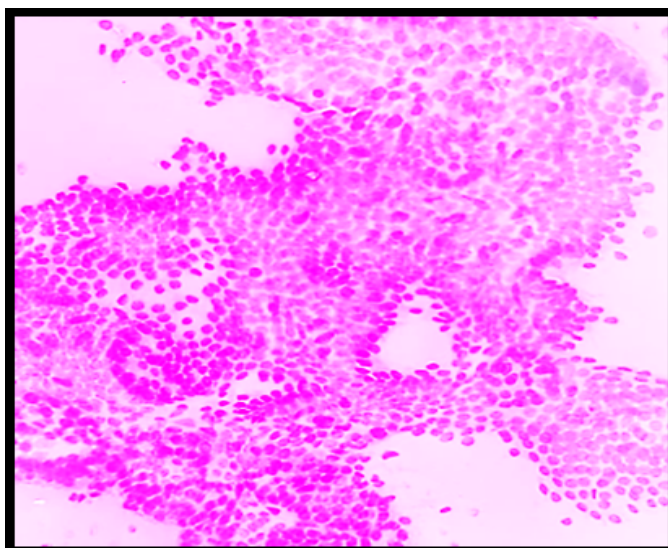


Fig. 7: 40X- Giemsa stain: Bethesda category-VI: Papillary Carcinoma Thyroid: FNAC moderately cellular smear show papillary fragments & singly scattered follicular cells with nuclear features of Papillary carcinoma-nuclear enlargement, crowding, overlapping, nuclear grooves, intranuclear inclusions & pale chromatin.

4 | DISCUSSION

Thyroid nodules are among the most frequently encountered endocrine lesions, and accurate preoperative diagnosis is essential for appropriate patient management. The present study evaluated the correlation between cytological findings, ultrasonographic features, and histopathological diagnosis in 261 thyroid lesions.

In the present study, females constituted 80.1% of cases, with the majority of patients belonging to the 21–40 years age group. Similar female predominance has been reported in previous studies and may be attributed to the higher prevalence of thyroid disorders among women. (1, 2)

Bethesda Category II lesions constituted the largest cytological group (67.4%), followed by Bethesda Categories III and IV. This distribution is comparable to that reported by Mondal et al. (1), Bongiovanni et al. (2), and Singh et al. (3), as shown in Table 6. The predominance of benign lesions highlights the usefulness of FNAC as an effective screening tool for thyroid nodules.

Ultrasonographic evaluation revealed that TI-RADS category TR3 was the most common category, followed by TR4 and TR2 lesions. The use of TI-RADS provides a standardized approach for risk stratification and facilitates identification of nodules requiring further cytological evaluation. Previous studies have demonstrated an increasing risk of malignancy with higher TI-RADS categories, supporting its utility in routine clinical practice. (8, 9)

Correlation of FNAC findings with histopathology demonstrated a high degree of diagnostic concordance. Most cytologically benign lesions were confirmed as benign on histopathological examination, whereas the majority of suspicious and malignant cytological diagnoses correlated with malignant histopathological findings. Discordant cases were predominantly observed in indeterminate cytological categories, which continue to represent a diagnostic challenge.

In the present study, FNAC showed a sensitivity of 86.0%, specificity of 91.5%, and diagnostic accuracy of 89.3%. These findings are comparable with those reported by Layfield et al. and Gupta et al. (11)

, as summarized in Table 7. The high specificity observed in the present study emphasizes the reliability of FNAC in differentiating benign from malignant thyroid lesions.

Ultrasonography alone demonstrated good diagnostic performance; however, the combined application of FNAC and TI-RADS yielded the highest sensitivity, specificity, and diagnostic accuracy. Similar observations have been reported by Yoon et al. (10), highlighting the complementary roles of cytological and radiological assessment in thyroid nodule evaluation. The combined approach improves risk stratification and assists clinicians in making informed decisions regarding patient management.

The present study demonstrates that integration of Bethesda-based cytological reporting and ACR TI-RADS classification enhances diagnostic accuracy and provides a reliable approach for the preoperative assessment of thyroid lesions.

Table 6. Comparison of Bethesda Category Distribution with Other Studies

Study	Bethesda II (%)	Bethesda III–IV (%)	Bethesda V–VI (%)
Mondal et al. ¹	68.4	18.2	13.4
Bongiovanni et al. ²	70.0	15.9	14.1
Singh et al. ³	66.0	21.3	12.7
Present study	67.4	19.1	13.5

Table 7. Comparison of Diagnostic Accuracy of FNAC with Other Studies

Study	Sensitivity (%)	Specificity (%)
Layfield et al.	83	92
Gupta et al. ¹¹	88	93
Present study	86.0	91.5

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Table 8. Comparison of TI-RADS Utility in Thyroid Lesions

Study	Key Observation
Horvath et al. ⁹	Malignancy risk increases with TI-RADS category
Tessler et al. ⁶	Standardized risk stratification
Yoon et al. ¹⁰	Improved accuracy with USG + FNAC
Present study	Highest accuracy with combined approach

5 | CONCLUSION

The present study demonstrates that fine-needle aspiration cytology (FNAC) remains a highly reliable and cost-effective diagnostic modality for the evaluation of thyroid lesions. The incorporation of ACR TI-RADS-based ultrasonographic risk stratification further enhances diagnostic accuracy and improves preoperative assessment of thyroid nodules. The combined cyto-radiological approach showed superior diagnostic performance compared with either modality alone and proved valuable in identifying lesions with a higher risk of malignancy.

The use of standardized reporting systems such as The Bethesda System for Reporting Thyroid Cytopathology and ACR TI-RADS facilitates effective communication among pathologists, radiologists, and clinicians, thereby enabling better risk stratification and informed clinical decision-making. Adoption of this integrated approach may help reduce unnecessary surgical interventions while ensuring timely diagnosis and appropriate management of malignant thyroid lesions.

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