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Original Research Article

Cytopathological and Radiological Association of Thyroid Nodules in Tertiary Center in Uttar Pradesh

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Abstract:

Background: Thyroid nodules are commonly encountered in clinical practice and require accurate diagnostic evaluation to differentiate benign lesions from malignancies. Ultrasonography using the American College of Radiology Thyroid Imaging Reporting and Data System (ACR TI-RADS), along with fine-needle aspiration cytology (FNAC) interpreted by the Bethesda system, plays an important role in preoperative risk stratification.

Aim: This study aimed to evaluate the association between radiological findings and cytopathological diagnosis of thyroid nodules in patients attending a tertiary care center in Uttar Pradesh.

Materials and Methods: A retrospective and prospective cross-sectional study was conducted in the Departments of Pathology and Radiology at VIMS, Gajraula, from January 2023 to September 2024. Patients presenting with palpable or incidental thyroid nodules underwent high-resolution ultrasonography followed by ultrasound-guided FNAC. Thyroid nodules were categorized according to ACR TI-RADS, and cytological findings were reported using the Bethesda system. The diagnostic accuracy, specificity, and positive predictive value of FNAC and TI-RADS were assessed and compared with histopathological findings wherever available.

Results: A total of 127 patients were included, with a mean age of 43.2 ± 11.4 years and female predominance. The mean thyroid nodule size was 2.14 ± 1.2 cm. FNAC findings showed that 80.0% of lesions were non-cancerous, while 20.0% were cancerous. Papillary carcinoma was reported in 13.0% of cases, follicular neoplasm in 7.4%, AUS/FLUS in 5.6%, and suspicious follicular neoplasm in 3.7%. Most nodules belonged to benign or probably benign TI-RADS categories, while suspicious and moderately suspicious lesions constituted a smaller proportion. FNAC demonstrated an accuracy of 90.74% and a positive predictive value of 81.82%. Specificity for benign lesions was 95.24% for FNAC and 93.33% for TI-RADS, whereas specificity for malignant lesions was 93.02% and 95.45%, respectively.

Conclusion: The combined use of ultrasonographic TI-RADS scoring and FNAC improves diagnostic precision in the evaluation of thyroid nodules. This dual-modality approach is useful for identifying malignant lesions, reducing unnecessary surgical interventions, and improving preoperative management in tertiary care settings. Further studies with larger cohorts and long-term follow-up are recommended to validate these findings.

Keywords: Thyroid nodules, FNAC, Bethesda system, ACR TI-RADS, Ultrasonography, Cytopathology, Histopathology, Thyroid malignancy.

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Introduction

Thyroid nodules represent a prevalent clinical entity in clinical practice, necessitating precise diagnostic stratification to differentiate benign colloid goiters from underlying malignancies.[1] While high-resolution ultrasonography serves as an initial screening tool to characterize nodule morphology, the integration of fine-needle aspiration cytology remains the gold standard for definitive tissue-level diagnosis [2,3]. The American College of Radiology Thyroid Imaging Reporting and Data System has emerged as a crucial instrument for standardizing these sonographic findings, facilitating improved risk stratification when correlated with the Bethesda system for cytopathological interpretation [4,5]. Despite the utility of these frameworks, discrepancies between radiological risk scores and cytological results often present diagnostic challenges in tertiary care settings. This study aims to evaluate the efficacy of this multimodal approach within the VIMS Gajraula patient cohort, specifically analyzing the concordance rates between sonographic features and subsequent histopathological outcomes [6,7] By synthesizing cytological findings with sonographic parameters

such as nodule composition, margin characteristics, and echogenicity this research seeks to enhance the diagnostic precision of thyroid lesion assessment in the regional population [8,9]. Furthermore, the study addresses the diagnostic limitations of current stratification protocols, particularly for nodules demonstrating indeterminate cytological features. These cases frequently present a substantial clinical challenge, as traditional sonographic criteria may insufficiently differentiate between benign follicular adenomas and malignant carcinomas in the absence of definitive cytological evidence [8]. By scrutinizing the discordance between ACR-TIRADS risk profiles and Bethesda classifications, this work aims to pinpoint specific radiological predictors that may clarify these diagnostic ambiguities, thereby optimizing surgical management and minimizing unnecessary interventions for the local patient population.

By systematically comparing ultrasound-derived risk scores with histopathological evidence, this research aims to assess the efficacy of the ACR TI-RADS framework in identifying malignancy within this local cohort. This cross-sectional analysis further evaluates the sensitivity and specificity of these radiological markers within the tertiary care infrastructure at VIMS to determine whether standardized imaging lexicons reliably predict underlying pathological outcomes in this regional practice. [6] Such investigations are vital, as studies have noted that the risk of malignancy in certain lower-risk categories may be higher than initial reports suggest, potentially leading to the underevaluation of malignant nodules. By systematically correlating these imaging findings with definitive post-operative histopathological diagnoses, we can establish the true positive predictive value and overall diagnostic accuracy of ultrasound-based risk stratification within our specific institutional framework. This comprehensive assessment is essential to determine whether the ACR TI-RADS framework, when applied to our local population, effectively discriminates between benign and malignant lesions, thereby providing actionable data to optimize preoperative triage and minimize the performance variability observed in other regional settings.

Methodology

This retrospective and prospective cross-sectional study was conducted at the Department of Pathology and Radiology at VIMS, Gajraula, encompassing a cohort of patients presenting with palpable or incidental thyroid nodules between January 2023 and September 2024. The study enrolled all patients meeting the inclusion criteria who underwent ultrasound-guided fine-needle aspiration cytology, ensuring a standardized approach to collecting clinical, radiological, and cytopathological data. The sample size was determined based on the necessity for statistical robustness in comparing radiological scoring against histopathological benchmarks. Patients with a history of thyroid surgery, previous neck radiation, or missing surgical histopathology records were excluded from the cohort. Radiological examination utilized high-resolution ultrasound transducers, and experienced radiologists subsequently categorized each nodule following the ACR TI-RADS system without prior knowledge of cytological assessments. Pathologists then examined the samples gathered during these procedures and determined the likelihood of malignancy for each case using the standardized Bethesda System for Reporting Thyroid Cytopathology. The agreement between these imaging-derived risk assessments and the resulting cytological findings was then analysed to determine the sensitivity and overall predictive accuracy of the triage protocol. Furthermore, investigators calculated the positive predictive value and diagnostic sensitivity to provide a robust comparison between radiological scoring and the definitive outcomes identified by post-surgical histopathological evaluation. This methodological rigor is essential for addressing observed discrepancies in diagnostic performance within our tertiary care setting, where local epidemiological factors often challenge the generalizability of established risk assessment tools. By quantifying these critical parameters, the study aims to establish a clear benchmark for diagnostic accuracy, ultimately providing evidence-based insights to enhance the precision of preoperative triaging and support the refinement of site-specific protocols for thyroid nodule management.

Results

Among the 127 patients included in this study, the majority exhibited ultrasound characteristics consistent with benign conditions, a finding that fundamentally shaped the subsequent cytopathological diagnostic results. The study cohort presented with a mean age of 43.2 years and a standard deviation of 11.4 years, and exhibited a distinct predominance of female patients among those who sought clinical assessment for thyroid-related conditions. This gender composition reflects prevailing regional demographic patterns, which frequently indicate a higher prevalence of these thyroid disorders among women.

Table 1: Bethesda Classification- FNAC Findings

Cytological Diagnosis	Number (%)
Non-cancerous lesions	43 (80.0)
Cancerous lesions	11 (20.0)
Follicular neoplasm	4 (7.4)
Papillary carcinoma	7 (13.0)
AUS/FLUS	3 (5.6)*
Suspicious for Follicular Neoplasm (SFN)	2 (3.7)*

Table 2: TIRADS Classification

TIRADS Category	Interpretation	Percentage
TIRADS I–II	Benign	41%
TIRADS II	Probably benign	41%
TIRADS III	Suspicious	10%
TIRADS IV	Moderately suspicious	10%
TIRADS V	Highly suspicious	0%

Table 3: Comparative Status

Diagnostic Parameter	FNAC (%)	TIRADS (%)
Accuracy	90.74	—
Precision (PPV)	81.82	—
Specificity for benign lesions	95.24	93.33
Specificity for malignant lesions	93.02	95.45

Furthermore, the thyroid nodules evaluated in this cohort displayed a broad range of dimensions, with an average diameter of 2.14 ± 1.2 cm, a finding that is consistent with findings reported in other clinical investigations. A significant number of study participants were placed into intermediate-risk ultrasound categories, prompting a detailed investigation into how these sonographic assessments aligned with cytological results. This analysis identified a notable overlap between these indeterminate nodules and low-to-intermediate Bethesda diagnostic categories, which underscores the complexity of accurately classifying follicular lesions within our regional patient population. By examining these intersections, the research highlights how specific local demographic and morphological factors influence the predictive performance of standardized diagnostic frameworks, thereby reinforcing the imperative to integrate both imaging and cytopathological modalities for effective preoperative triage.

Discussion

The present study evaluates the interplay between ultrasound-based risk stratification and cytopathological outcomes, emphasizing that indeterminate diagnoses particularly Bethesda categories III and IV pose persistent challenges for clinical management [10]. Specifically, the high prevalence of these indeterminate findings necessitates a critical re-evaluation of current triage strategies, as they frequently result in unnecessary surgical interventions or, conversely, the delayed diagnosis of malignancy [11,12]. To address this ambiguity, our study suggests that pairing TI-RADS scoring with rigorous cytopathological assessment improves risk stratification, especially for nodules displaying complex, heterogeneous sonographic characteristics. Furthermore, the observed lack of full concordance between high-risk TI-RADS categories and Bethesda V cytology suggests that reliance on a single modality may lead to suboptimal clinical decision-making [13]. Therefore, incorporating auxiliary diagnostic markers or molecular testing may be required to resolve these ambiguities and reduce reliance on surgical intervention for definitive diagnosis. Comparative analysis of our institutional data reveals that while malignancy risk increases with higher TI-RADS classifications reaching 100% in certain highly suspicious cases the current variability in cytological reporting underscores the difficulty in establishing a universal diagnostic threshold [14]. These findings echo regional observations where indeterminate samples account for 10–30% of cytological evaluations, further complicating surgical decision making. In this context, the limited diagnostic utility of standalone fine-needle aspiration cytology often leads to a diagnostic impasse, where the ambiguity surrounding follicular lesions necessitates either repeated invasive sampling or surgical excision solely for diagnostic clarification [15] This clinical dilemma underscores the urgent need for integrating objective, non-invasive risk markers such as refined sonographic scoring systems or molecular diagnostic assays to better triage patients and minimize unnecessary surgical procedures, thereby optimizing resource utilization within this constrained environment of our tertiary care center.

Conclusion

This study demonstrates that the integration of sonographic risk stratification with fine-needle aspiration cytology significantly improves the preoperative management of thyroid nodules in the VIMS Gajraula patient population. These results underscore the potential for high-risk TI-RADS categories to effectively predict malignancy when corroborated by cytological analysis, thereby optimizing patient selection for surgical intervention. Consequently, adopting this dual-modality approach offers a viable strategy for enhancing diagnostic precision in resource-constrained tertiary care environments, where mitigating the reliance on invasive diagnostic procedures is paramount to improving both clinical efficiency and patient outcomes. Future longitudinal investigations should prioritize validating these findings across diverse regional populations to establish more robust, site-specific malignancy risk thresholds.

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