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Integrated evaluation of thyroid nodules: correlation of ultrasound features with fine needle aspiration cytology using the Bethesda system

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ABSTRACT

Objectives: This study aimed at correlation of ultrasound findings with fine needle aspiration cytology (FNAC) results using the Bethesda system, providing insights into thyroid nodule pathology.

Material and Methods: A retrospective analysis involving 104 patients was performed at Punjab Institute of Nuclear Medicine (PINUM) between July 5, 2023, and July 1, 2024. The study encompassed patients of all ages and genders diagnosed with cold thyroid nodules (solitary and with multinodular goiter) through thyroid nuclear scans. The exclusion criteria included diffuse goiter, hot nodules, recurrent thyroid cancers, and metastases. Ultrasound evaluations included the assessment of nodule composition and FNAC outcomes were classified according to the Bethesda system. Statistical analysis was conducted using SPSS version 24, with a significance threshold set at a *p*-value of less than 0.05.

Results: The majority of patients were female (94%), with the right side being the most frequently affected (57%). Benign cases dominated in all nodule categories. Solid single nodules demonstrated an increased risk of follicular neoplasm and malignancy. Spongiform nodules were primarily benign. Ultrasound findings demonstrated an 80% correlation with fine needle aspiration cytology outcomes.

Conclusion: Ultrasound, in conjunction with FNAC as reported on the Bethesda system, is highly useful in discriminating benign and malignant thyroid nodules, and it is suggested as a primary screening method for patients with thyroid nodules.

Keywords: Ultrasound (US), fine needle aspiration cytology (FNAC), thyroid nodule (TN).

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Introduction

Thyroid diseases represent a major global challenge in endocrine health, with thyroid nodules being among the most common disorders impacting a large segment of the population. In areas where iodine levels are adequate, around 5% of women and 1% of men exhibit palpable thyroid nodules. In regions where iodine is deficient, the prevalence significantly increases, varying from 20% to as much as 76% [1,2]. Thyroid disorders, including nodules, are prevalent yet often overlooked in numerous areas, particularly in nations such as Pakistan. The lack of awareness, inadequate screening initiatives, and limited access to healthcare in rural and underserved regions intensify the impact of these conditions on public health.

Thyroid nodules, frequently observed in cases of endocrine dysfunction, require prompt and accurate assessment

to differentiate between benign and malignant conditions. The distinction is essential since malignant nodules necessitate prompt surgical action to prevent disease progression, while benign nodules, though not as urgent/lethal, can still result in notable cosmetic and symptomatic concerns. Individuals with benign nodules frequently encounter symptoms such as dysphagia, neck pain, or breathing difficulties, highlighting the necessity for thorough management approaches [3,4].

Fine needle aspiration cytology (FNAC) and ultrasound (US) have become essential diagnostic methods in evaluating thyroid nodules. FNAC is widely recognized for its excellence in cytological evaluation, offering essential insights into the cellular makeup of nodules. The Bethesda System for Reporting Thyroid Cytopathology (TBSRTC) has significantly improved the application of

FNAC through the implementation of a standardized six-tier categorization framework. Every category outlines particular risks associated with malignancy and guides clinical management choices, thus enhancing diagnostic accuracy [5,6].

Ultrasound acts as an adjunct to FNAC, providing immediate visualization of nodule structure, blood flow, and calcification. The combination of US and FNAC significantly improves diagnostic accuracy by compensating for the inherent limitations present when each method is utilized on its own. For example, ultrasound is highly effective in detailing the characteristics of nodules, whereas FNAC offers conclusive cytological validation [7,8].

The present study aimed to establish a robust correlation between ultrasound findings and FNAC results, utilizing the advantages of both techniques to enhance the accuracy of the diagnosis and optimal management of thyroid nodules. The study seeks to enhance the clinical framework for managing thyroid nodules by thoroughly evaluating these diagnostic tools, with the ultimate goal of improving patient care.

Material and Methods

Study design

A retrospective study involving 104 patients diagnosed with thyroid nodules was conducted at Punjab Institute of Nuclear Medicine between July 5, 2023, and July 1, 2024. All patients presented with neck swelling, with or without associated symptoms.

Inclusion and exclusion criteria

Included: Patients of all ages and genders with cold nodules on thyroid scans (solitary and with multinodular goiter).

Excluded: Cases with diffuse goiter, hot nodules, recurrent thyroid cancers, or metastases.

Data collection and analysis

Ultrasound evaluations assessed nodule composition. FNAC was performed in all patients having cold nodules using a 23-G needle, and cytological findings were categorized per the Bethesda system. Statistical analysis employed SPSS version 24, and a *p*-value of less than 0.05 was considered statistically significant.

Results

Demographics

The study cohort *n* = 104, comprised 94% females and 6% males, with a mean age of 37.6 ± 12.5 years. Right-sided nodules predominated *n* = 57 (55%).

Ultrasound findings

Figure 1 provides an overview of the ultrasound characteristics of nodules and their corresponding frequencies. Most nodules were classified as benign across all ultrasound categories. Solid single nodules had the highest incidence of follicular neoplasm (8 cases) and were the only category with a malignancy reported (1 case). Spongiform nodules were predominantly benign, with only one case of follicular neoplasm observed in the spongiform, multiple categories. Similarly, solid/cystic nodules were largely benign, with no cases of malignancy identified.

FNAC results

Figure 2 illustrates the FNAC findings of nodules and their corresponding frequencies. The majority of nodules were benign (II), accounting for 79 cases (76%). Atypia of undetermined significance (AUS, III) was observed in 9 cases (8.7%), while follicular neoplasm (FN, IV) was identified in 12 cases (11.5%). Suspicious for malignancy (V) was noted in 3 cases (2.9%), and only 1 case (1%) was classified as malignant (VI).

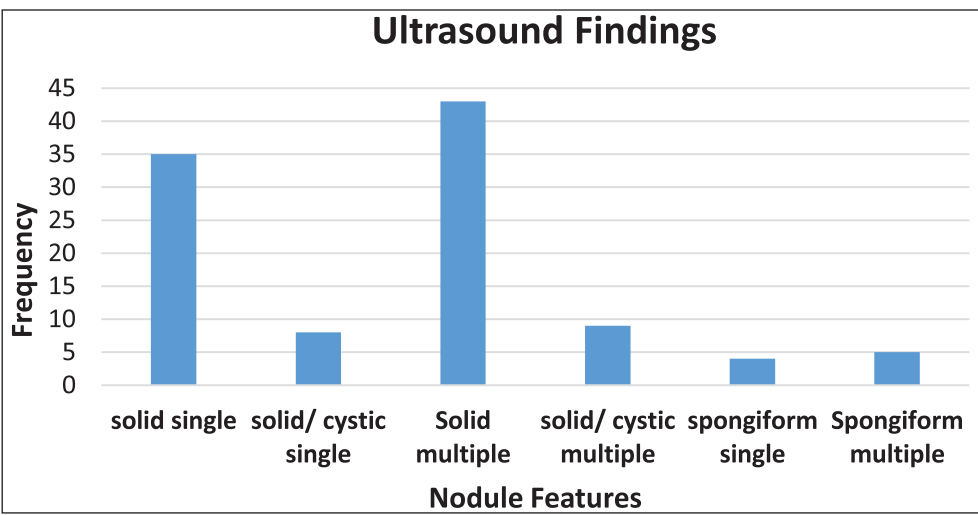


Figure 1. Ultrasound features of nodules with their frequencies.

Correlation and accuracy

Table 1 summarizes the distribution of FNAC results across various ultrasound nodule types. The nodules are categorized based on their composition (solid, solid/cystic, or spongiform) and number (single or multiple). The FNAC outcomes include classifications such as benign, atypia of undetermined significance (AUS), follicular neoplasm, suspicious for malignancy, and malignant. Ultrasound findings aligned with FNAC results in 80% of cases, demonstrating its reliability as a noninvasive screening tool.

Discussion

This study underscores the essential role of US and FNAC in the evaluation and management of thyroid nodules. These tools, both individually and collectively, remain foundational in the diagnosis of thyroid nodules, enabling clinicians to accurately differentiate between benign and malignant thyroid tumors. The results of this study align with global statistics, further corroborating the recognized efficacy of ultrasound and fine needle aspiration cytology in clinical practice.

A considerable female predominance in thyroid nodule instances has been observed, consistent with findings from many global researchers. Thyroid problems, especially

nodules, disproportionately affect women, a phenomenon typically ascribed to hormonal and hereditary influences [9]. The predominance of females highlights the necessity of customizing public health campaigns and clinical screening programs to meet the demands of this demographic. Early detection and targeted management strategies could significantly reduce the burden of thyroid disorders among women, who represent a high-risk demographic in both iodine-sufficient and iodine-deficient regions.

The study’s findings regarding solid single nodules further emphasize their potential for malignancy. Among the nodule categories evaluated, solid single nodules demonstrated the highest malignancy potential, corroborating the conclusions of prior research conducted by Al-Ghanimi et al. [8] and Isse et al. [9]. These studies similarly identified solid nodules as a critical area of concern, underscoring the need for meticulous evaluation in patients presenting with such nodules. The heightened malignancy risk associated with solid single nodules necessitates their prioritization in diagnostic workflows, ensuring that appropriate interventions are initiated without delay. This emphasis on early detection is particularly relevant in settings with limited access to advanced healthcare facilities, where

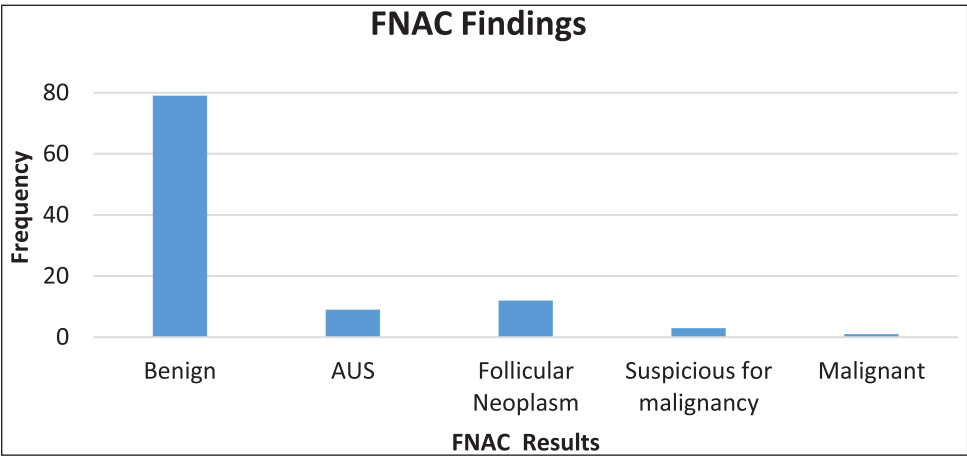


Figure 2. FNAC results with their frequencies.

Table 1. Distribution of FNAC results by ultrasound nodule characteristics.

FNAC	Ultrasound features						Total
	Solid single	Solid/cystic single	Solid multiple	Solid/cystic multiple	Spongiform single	Spongiform multiple	
Benign	20	7	37	7	4	4	79
AUS	4	1	2	2	0	0	9
Follicular Neoplasm	8	0	3	0	0	1	12
Suspicious for malignancy	2	0	1	0	0	0	3
Malignant	1	0	0	0	0	0	1
Total	35	8	43	9	4	5	104

delayed diagnosis can have severe implications for patient outcomes.

Another key contribution of this study is its use of the TBSRTC. This system offers a standardized framework for the cytopathological evaluation of thyroid nodules, providing clear guidelines for classification and management [6,7]. By categorizing FNAC findings into six distinct tiers, the Bethesda system facilitates more precise risk stratification and informs clinical decision-making. Its application in this study highlights its utility in enhancing diagnostic clarity and consistency, particularly in complex cases where the distinction between benign and malignant lesions may be challenging. The systematic approach provided by the Bethesda system also supports more consistent communication among healthcare providers, enabling more cohesive and effective patient care [10, 11].

The benign nature of spongiform nodules, as observed in this study, is consistent with findings from previous research [12]. Spongiform nodules are characterized by their specific ultrasound features, which contribute to their high specificity as benign lesions. This reinforces the value of ultrasound as a noninvasive diagnostic tool capable of providing critical insights into nodule characteristics. The identification of benign patterns, such as those seen in spongiform nodules, enables clinicians to reduce unnecessary invasive procedures, thereby improving patient outcomes and optimizing resource utilization. In resource-limited settings, the ability to confidently classify nodules as benign based on ultrasound findings alone could play a pivotal role in reducing the burden on healthcare systems.

Despite its strengths, this study has limitations that must be acknowledged. Notably, additional radiological features, such as vascularity, perilesional halo, and height-to-width ratios, were not evaluated. These features are increasingly recognized as important parameters in the assessment of thyroid nodules, and their exclusion limits the ability to fully compare the subtle characteristics of benign and malignant lesions. Future studies should incorporate these parameters to provide a more comprehensive evaluation and further refine the diagnostic process. Additionally, a larger sample size and multicenter data collection would enhance the generalizability of the findings and allow for more robust comparisons across different demographic and clinical settings.

Recent advancements in imaging technology present exciting opportunities to enhance the precision of thyroid nodule evaluation. Techniques, such as elastography, which measures tissue stiffness, and AI-driven diagnostic models, are gaining traction in clinical practice. Elastography has shown promise in differentiating benign from malignant nodules based on their elasticity, while AI algorithms offer the potential to analyze large datasets and identify patterns that may be missed by human observers [13,14]. These innovations, when integrated

with established methods such as US and FNAC, could revolutionize the diagnostic landscape, enabling earlier and more accurate detection of thyroid malignancies. The incorporation of these advanced technologies also holds the promise of standardizing diagnostic processes across varied healthcare settings, ensuring equitable access to high-quality care.

To summarize, this study underscores the enduring value of ultrasound and FNAC in thyroid nodule evaluation. By reaffirming the established utility of these diagnostic tools and highlighting areas for future research, it provides a robust foundation for improving clinical practice. Incorporating advanced imaging techniques and addressing the study's limitations will further enhance the diagnostic accuracy and management of thyroid nodules, ultimately benefiting patients and advancing the field of thyroidology. Future research should prioritize the integration of cutting-edge technologies, large-scale studies, and the exploration of novel biomarkers to continually refine the standards of thyroid nodule evaluation and care.

Conclusion

Ultrasound, when combined with FNAC and the Bethesda system, effectively differentiates benign from malignant thyroid nodules. This study underscores the importance of integrating these diagnostic tools into routine clinical practice for thyroid disorder management. Future research should explore the role of emerging imaging technologies and AI in thyroid nodule assessment.

List of Abbreviations:

AUS	Atypia of undetermined significance
FN	Follicular neoplasm
FNAC	Fine needle aspiration cytology
TBSRTC	Bethesda system for reporting thyroid cytopathology
US	Ultrasound

Conflict of interests

The authors declare that there is no conflict of interest regarding the publication of this article.

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Consent to participate

Informed written consent was taken from all the patients included in this study.

Ethical approval

The approval of this study was obtained from the Ethical Committee of PINUM Cancer Hospital. PINUM-Estt-1(28)/13).

Availability of data and materials

This can be provided upon reasonable request.

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