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Integrated Role of TI-RADS and Bethesda Classification in the Evaluation and Management of Suspicious Thyroid Nodules: A Review

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Abstract

Combining the Thyroid Imaging-Reporting and Data System (TI-RADS) and the Bethesda Classification significantly improves the diagnostic accuracy of identifying malignant thyroid nodules compared to using either system alone. While TI-RADS uses ultrasound features to stratify risk, the Bethesda system classifies cytopathological results from fine-needle aspiration (FNA). Currently, the primary diagnostic procedures for assessing nodular goiter before surgery include thyroid gland ultrasonography and ultrasound-guided fine-needle aspiration biopsy (FNAB). The assessment of the accuracy of the Thyroid Imaging Reporting and Data System (TI-RADS) in conjunction with the Bethesda Classification plays an important role in improving the management of suspicious thyroid nodules. TI-RADS is an ultrasound-based risk stratification system designed to categorize thyroid nodules according to their likelihood of malignancy based on features such as composition, echogenicity, margins, calcifications, and shape. On the other hand, the Bethesda System for Reporting Thyroid Cytopathology classifies fine-needle aspiration (FNA) cytology results into six categories, each associated with a defined risk of malignancy and recommended clinical management. When used together, these two systems provide complementary diagnostic information that enhances clinical decision-making. In conclusion, the combined use of TI-RADS and the Bethesda Classification enhances the accuracy of diagnosing and managing suspicious thyroid nodules. Their integration provides a more reliable risk stratification framework, reduces unnecessary interventions, and improves patient outcomes. However, careful interpretation and correlation with clinical findings remain essential to optimize their effectiveness.

Introduction

Combining the Thyroid Imaging-Reporting and Data System (TI-RADS) and the Bethesda Classification significantly improves the diagnostic accuracy of identifying malignant thyroid nodules compared to using either system alone. While TI-RADS uses ultrasound features to stratify risk, the Bethesda system classifies cytopathological results from fine-needle aspiration (FNA) [(1)].

Preoperative Assessment of Thyroid Nodules

Currently, the primary diagnostic procedures for assessing nodular goiter before surgery include thyroid gland ultrasonography and ultrasound-guided fine-needle aspiration biopsy (FNAB). Increasingly, the decision to proceed with surgery for thyroid focal lesions is informed by molecular techniques that reveal potential mutations and epigenetic alterations, which are crucial in the process of malignant transformation [(2)].

Ultrasonographic Assessment

Ultrasonography serves as an invaluable diagnostic modality for assessing focal thyroid lesions, particularly in the context of multinodular goiter, as it facilitates the identification of areas amenable to fine needle aspiration biopsy. It is now acknowledged that the primary determinants of a thyroid nodule's malignant potential are not its size, but rather its vascularization, presence of microcalcifications, height-to-width ratio, structural composition (whether solid or solid-fluid), echogenicity, border margins, and presence of a halo. Consequently, thyroid nodules with a higher likelihood of malignancy exhibit the following ultrasonographic

characteristics: increased central vascularization or absence of flow in power Doppler; microcalcifications; a height exceeding the width; solid lesions are more concerning than those with both solid and fluid components; hypoechogenic lesions are more alarming than isoechogenic ones; lesions with irregular margins and those lacking a halo or possessing an irregular, thick halo are more suspicious[3].

Fine-Needle Aspiration Biopsy and Bethesda Classification

In contemporary medical practice, ultrasound-guided FNAB is considered the definitive method for diagnosing nodular goiters. This procedure is straightforward, safe, and cost-effective. Cytological assessment of samples collected using this biopsy method adheres to the international classification known as the Bethesda System for Reporting Thyroid Cytopathology.

According to this system, the outcomes of fine-needle aspiration biopsy of a thyroid nodule are divided into six diagnostic cytopathology categories: I, nondiagnostic or unsatisfactory; II, benign; III, atypia of undetermined significance or follicular lesion of undetermined significance; IV, follicular neoplasm or suspicious for a follicular neoplasm; V, suspicious for malignancy; and VI, malignant. Categories IV, V, and VI diagnoses generally necessitate surgical intervention [4].

Recommendations are also made for diagnoses in groups III and I. It is crucial to recognize that even a benign diagnosis (group II) from a fine-needle aspiration biopsy carries a 3% risk of false-negative results.

Thyroid Imaging Reporting and Data System

The Thyroid Imaging Reporting and Data System (TI-RADS) was introduced as a uniform approach for assessing and documenting thyroid ultrasound results, as well as for evaluating risk, to facilitate interpretation and ensure consistency among professionals[5].

Fine needle aspiration (FNA) biopsy of the thyroid has been adopted as a fundamental procedure for diagnosing suspicious nodules indicated by Thyroid Imaging Reporting and Data System (TI-RADS). Bethesda System recommended by the American thyroid association (ATA) to report the results of FNA. The Bethesda System showed a relatively high accuracy in reporting FNA cytology, with 89% of samples being satisfactory for interpretation, 74% reported as definitively benign and 5% as definitively malignant[6].

Indeterminate Cytology and Surgical Management

However, approximately 20–30% of the cytology samples still belong to indeterminate diagnostic results, that is, Bethesda categories III–V (III: unclear cellular atypical lesion or unclear follicular lesion AUS/FLUS; IV: follicular lesion or suspicious follicular tumor SFN/FN; V: suspicious malignant tumor SM), with a certain degree of malignancy. Then, in order to obtain a definitive diagnosis, surgery is selected by a number of patients with nodules in these cytological categories[7].

Due to the aggressively biopsying small nodules and performing extensive surgeries, the detection rate of thyroid cancer has increased dramatically in recent decades. However, the overall mortality rate of thyroid cancer is not significant, and thyroid cancer remains one of the least deadly human cancers. With the increasing cost of surgery, which proves 4.7–6.5 times more expensive than active surveillance, the excessive medical treatments in thyroid nodules are brought into focus. Therefore, it is imperative to diagnose malignant lesions among indeterminate thyroid nodules precisely to avoid unnecessary operations and achieve a good cost effectiveness[8].

Combined Use of TI-RADS and Bethesda Classification

The assessment of the accuracy of the Thyroid Imaging Reporting and Data System (TI-RADS) in conjunction with the Bethesda Classification plays an important role in improving the management of suspicious thyroid nodules. TI-RADS is an ultrasound-based risk stratification system designed to categorize thyroid nodules according to their likelihood of malignancy based on features such as composition, echogenicity, margins, calcifications, and shape. On the other hand, the Bethesda System for Reporting Thyroid Cytopathology classifies fine-needle aspiration (FNA) cytology results into six categories, each associated with

a defined risk of malignancy and recommended clinical management. When used together, these two systems provide complementary diagnostic information that enhances clinical decision-making[5] .

TI-RADS has good sensitivity in identifying potentially malignant nodules, particularly in higher categories (e.g., TI-RADS 4 and 5). However, its specificity can vary, leading to some benign nodules being classified as suspicious. The Bethesda classification, derived from cytological examination, provides a more definitive assessment, especially in clearly benign (Category II) or malignant (Category VI) cases. The combination of TI-RADS and Bethesda helps reduce unnecessary biopsies and surgeries by correlating imaging findings with cytopathological results. For instance, nodules with low TI-RADS scores and benign Bethesda results can often be safely monitored, while those with high-risk features in both systems warrant more aggressive management[6].

Concordant and Discordant Findings

The diagnostic accuracy improves significantly when there is concordance between TI-RADS and Bethesda categories. High TI-RADS scores combined with higher Bethesda categories (IV–VI) strongly predict malignancy, increasing positive predictive value. Conversely, discordant findings such as a high TI-RADS score with benign cytology may require repeat FNA, molecular testing, or close follow-up, as false negatives can occur in cytology. This integrated approach minimizes diagnostic uncertainty and supports individualized patient care[3].

Limitations

Despite their usefulness, both systems have limitations. TI-RADS is operator-dependent and may vary based on the radiologist's experience, while Bethesda classification can be affected by sampling errors or indeterminate results (Categories III and IV), which present diagnostic challenges. Therefore, clinical judgment, patient history, and additional diagnostic tools must be considered alongside these systems[4].

Conclusion

In conclusion, the combined use of TI-RADS and the Bethesda Classification enhances the accuracy of diagnosing and managing suspicious thyroid nodules. Their integration provides a more reliable risk stratification framework, reduces unnecessary interventions, and improves patient outcomes. However, careful interpretation and correlation with clinical findings remain essential to optimize their effectiveness[7].

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