Section: Miscellaneous

Original Research Article

EVALUATION OF TI-RADS AND BETHESDA SYSTEM FOR REPORTING THYROID CYTOPATHOLOGY WITH HISTOPATHOLOGY CORRELATION

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ABSTRACT

Background: The accurate preoperative evaluation of thyroid nodules is critical for guiding clinical management and minimizing unnecessary procedures. While TI-RADS and Bethesda systems are widely used radiologic and cytological categorization of thyroid nodules, their diagnostic concordance needs further evaluation.

Materials and Methods: This retrospective observational study analyzed 100 thyroidectomy cases with preoperative ultrasound (TI-RADS) and fine needle aspiration cytology (Bethesda system). Diagnostic performance metrics—sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy—were calculated for both systems, using histopathology as the gold standard

Results: The risk of malignancy increased with higher TI-RADS and Bethesda categories. Combined diagnostic accuracy of TI-RADS and Bethesda categories was higher than when considered alone. The area under the ROC curve was higher for Bethesda system (0.842) than TI-RADS (0.79), indicating superior diagnostic accuracy for cytology.

Keywords: Thyroid nodule, TI-RADS, Bethesda system, Diagnostic accuracy.

INTRODUCTION

Thyroid nodules are a focal, well-defined area with distinct radiological features, distinguishable from adjacent thyroid parenchyma. Global prevalenceof thyroid nodules is 4-8%, with a slightly higher prevalence in India.[1-2] Radiological imaging, particularly ultrasound (USG), is essential for initial thyroid nodule assessment. The Thyroid Imaging Reporting and Data System (TI-RADS), based on certain sonological features, provides a structured reporting framework, recommending fine needle aspiration cytology(FNAC) for nodules based on size and suspicion of malignancy. FNAC of thyroid nodules is usually analyzed using the Bethesda System of Reporting Thyroid Cytopathology (TBSRTC). Like TIRADS, the Bethesda system categorizes FNAC results into six categories, each with an associated risk of malignancy and recommended clinical management. Ultrasound features of thyroid nodules sometimes don't align with the cytology results, causing diagnostic discrepancies. Hence, histopathology is the gold standard for diagnosing thyroid nodules.[3-5]

The aim of our study was to:

1. Tocorrelate preoperative TI-RADS score and FNAC results with subsequent histological diagnosis
2. To assess the utilization and the diagnostic performance of each category of Bethesda and TI-RADS score, including the sensitivity, specificity, accuracy, and positive and negative predictive values for malignancy within the patient population

MATERIALS AND METHODS

This study was approved by the Institutional Ethics Committee with IEC no. IEC/MES/F6/2025. This was a retrospective observational study of 100 thyroidectomy cases with thyroid nodules who underwent preoperative USG and FNAC. The FNAC

cohort included samples obtained through both conventional palpation-guided and USG-guided FNAC. Cases with inadequate or sub-optimal cytology smears and cases with USG report of TI-RADS 1 were excluded from the study. The TI-RADS system, which is a standardized scoring system based on composition, echogenicity, shape, margin, and echogenic foci, was used for all the USG reporting of thyroid nodules.[4] All cytology reports were based on the Bethesda System for Reporting Thyroid Cytopathology, with each case assigned to one of six categories5. Category I was not included in the study. Statistical analysis was done using SPSS 26 and the Med-Calc software. Descriptive data is presented in terms of frequency and percentage distribution. The performance data of sensitivity, specificity, predictive values and accuracy were calculated for TI-RADS, BETHESDA with histopathology as gold standard.

RESULTS

This study retrospectively analysed 100 cases between the ages of 18 and 75 years, with the majority being females and a male-to-female ratio of 1:6.1. The manage of the participants was 45.4 years. Histopathology diagnosis.

The majority of the cases were benign (62%), and 38% of the cases were malignant

Table 1: Histopathology diagnosis

Diagnosis	Number(n)	Percentage(%)
Thyroid follicular nodular disease	48	48
Hashimoto's thyroiditis	9	9
Follicular adenoma	3	3
Oncocytic adenoma	2	2
Non-invasive Follicular Thyroid Neoplasm with Papillary-like Nuclear Features (NIFTP)	1	1
Follicular carcinoma	4	4
Papillary thyroid carcinoma	30	30
Follicular variant of papillary carcinoma	3	3
Total	100	100

TI-RADS

TI-RADS categories were distributed as 2(16%),3(30%),4(31%) and 5(23%).WhencorrelatingTI-RADS andBethesdacategories, wefound that15 outof 16 TI-RADS 2 lesions were diagnosed as benign in cytology (Bethesda II). For TI-RADS 3 and 4 lesions, 71% were identified as benign in cytology, while the remaining cases were categorized as intermediate (Bethesda III, IV, and V). Out of 23 TI-RADS 5 lesions, only one was found to be benign in cytology. Onhistopathologicalanalysis,63caseswerebenign,and 37weremalignant.

Accordingtothestudy,thecorrelationbetweenTI-RADSandhistopathological data showedthat out of all TI-RADS 2cases, 87.5% were found to be benign in histologyand12.5%malignant.Similarly,outof61patientswithTI-RADS3and 4, 73.8% were found to be benign, while the remaining 16 were malignant.

Lastly,outof23patientsclassifiedasTI-RADS5,78.3%werediagnosedas malignant, and five were benign. Theriskofmalignancy(ROM)inTIRADScategoriesincreasedfrom12.5%in TIRADS 2 to 82.6% in TIRADS 5.

Bethesda

The distribution of Bethesda categories was as follows: 61% category II,14% category III,2% category IV,19% category V, and 1% category VI. According to the correlation of histopathological findings with Bethesda categories,88.5%ofcasescategorisedasBethesdaIIwerefoundtohavea benigndiagnosisinhistology.Ontheotherhand,57.2%ofcasescategorisedas Bethesda III were confirmed to be malignant. Meanwhile, the combined percentageofmalignancyinhistologyfor the Bethesdaintermediatecategories(III, IV, and V) was 80%. All cases categorized as Bethesda category VI had a malignant histology diagnosis. Theriskofmalignancy(ROM)increaseswithincreasing Bethesda category,rangingfrom11.5%inCategoryIIto100%inCategoryVI.Categories III, IV, and V combined have an 80% ROM.

Diagnostic accuracy of TI-RADS and Bethesda

Thesensitivity,specificity,positivepredictivevalue(PPV), negative predictive value (NPV), and accuracy were calculated based on histopathological results. TI-RADS 2 and 5 showed the highest sensitivity and PPV. Bethesda categories II and VI had high specificity and PPV, and when intermediatecategories(III+IV+V)werecombined,the resultswerealsohigh. The accuracy was 100% in the Bethesda category VI (Table 2). Bethesda categories II and VI had high specificity and PPV, and when intermediate categories (III+IV+V) were combined, the results were also high. The accuracy was 100% in Bethesda category VI (Table 3).

Table 2: Performance data of TI-RADS

	TI-RADS2	TI-RADS3&4	TIRADS5
SENSITIVITY	22.22%	43.24%	51.35%
SPECIFICITY	94.59%	28.57%	93.65%
POSITIVEPREDICTIVE VALUE	87.50%	26.23%	82.61%
NEGATIVEPREDICTIVE VALUE	41.67%	46.15%	76.62%
ACCURACY	49.00%	34.00%	78.00%

Table 3: Performance data of BETHESDA

	BETHESDAII	BETHESDA III, IV & V	BETHESDAVI
SENSITIVITY	85.71%	75.68%	2.70%
SPECIFICITY	81.08%	90.48%	100.00%
POSITIVEPREDICTIVEVALUE	88.52%	82.35%	100.00%
NEGATIVEPREDICTIVE VALUE	76.92%	86.36%	63.64%
ACCURACY	84.00%	85.00%	64.00%

The area under the ROC curve measures accuracy. The area under the ROC curve for TIRADS and Bethesda was 0.791 and 0.842, respectively (Figure 1).

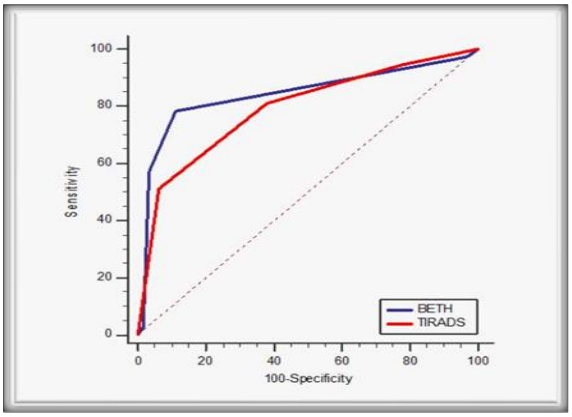

Figure 1: ROM of TI-RADS and BETHESDA

DISCUSSION

In our study, the mean age of patients with thyroidlesionswas45.5±12.5 years. Theage range for benign cases was 18-75yrs, while for malignant cases it was 32-72yrs. The male to female ratio in our study was 1:6.1. This is similar to the data from the study conducted in the Philippines by Grace Dyetal,[6] with a male to female ratio of 1:6.[7] The M:F ratioina similar study conducted bySrinivasetal7 was 1:15.5 and only 1:3 in a study conducted by Osseis et al.[8]

Our study found ROMs for TIRADS categories as follows:12.5%(TR2) ,16.7%(TR3) ,35.5%(TR4) and 82.6% (TR5), compared to Hess et al's9 study :9.3%(TR2),16.6(TR3),27%(TR4) and 76.5%(TR5). The ROM for TR 3 and TR 4 was slightly higher in our study compared to theirs. In this study, the ROM for BIRADS categories was 11.5%(II),57.2%(III),100%(IV),94.7%(V) and 100%(VI) compared to Osseis et al's study8:20%(II),54.4%(III),34.2%(IV),88.89%(V) and 100%(VI). There is a significant difference between ROM of category IV in our study and the study conducted by Osseis et al, this may be because we considered the intermediate categories like NIFTP as malignant in our study.

When considering the diagnostic accuracy of TI-RADS, TI-RADS 5 had the highest sensitivity and TI-RADS 2 had the highest specificity, but in the study conducted by Hess et al,[9] the highest sensitivity was for TI-RADS 2 and the highest specificity was for TI-RADS 5 (Table 4).In our study, TI-RADS 3 and 4, when combined, had a better sensitivity of 43.24%.

Table 4: Comparison of diagnostic accuracy of TI-RADS

Our study	SENSITIVITY	SPECIFICITY	PPV	NPV	ACCURACY
TI- RADS2	22.2	94.6	87.5	41.7	49.0
TI- RADS3	13.5	60.3	16.7	54.3	43.0
TI- RADS4	29.7	68.3	35.5	62.3	54.0
TI- RADS5	51.4	93.7	82.6	76.7	78.0
Hess et al[9]	SENSITIVITY	SPECIFICITY	PPV	NPV	ACCURACY
TI-RADS2	97.0	7.3	45.7	75.0	47.3
TI-RADS3	97.0	22.0	50.0	90.0	55.4
TI-RADS4	72.7	43.9	51.1	66.7	56.8
TI-RADS5	36.4	87.8	70.6	63.2	64.9

Table 5: Comparison of diagnostic accuracy of BIRADS

Our study	SENSITIVITY	SPECIFICITY	PPV	NPV	ACCURACY
BethesdaII	85.71%	81.08%	88.52%	76.92%	84.00%
BethesdaIII	22.22%	90.62%	57.14%	67.44%	66.00%
BethesdaIV	5.14%	100.00%	100.00%	64.29%	65.00%
BethesdaV	48.65%	98.41%	94.74%	76.54%	80.00%
BethesdaVI	2.70%	100.00%	100.00%	63.64%	64.00%
Tanetal [13]	**SENSITIVITY**	**SPECIFICITY**	**PPV**	**NPV**	**ACCURACY**
BethesdaII	89.50%	93.30%	97.50%	75.27%	90.50%
BethesdaIII	90.00%	94.30%	97.90%	75.86%	91.10%
BethesdaIV	75.50%	100.00%	100.00%	58.14%	81.70%
BethesdaVI	71.40%	100.00%	100.00%	54.35%	78.60%

Several studies, including those conducted by Avior et al,[14] Canberk et al,[15] and Kim et al,[16] have shown that grouping Bethesda categories leads to better performance. This study also found better performance when intermediate categories (III+IV+V) were grouped instead of being considered separately.

Table 6: ?

STUDY	CATEGORY	SENSITIVITY	SPECIFICITY	PPV	NPV	ACCURACY
Ourstudy	III-V	75.7%	90.5%	82.4%	86.4%	85.0%
AviorGet al [14]	V–VI	90%	97%	94%	95%	95%
AviorGet al [14]	III–IV	91%	73%	62%	95%	79%
Canberket al [15]	V–VI	69%	88%	87%	71%	72%
Canberket al [15]	III–VI	90%	51%	68%	81%	78%
Kimetal [16]	V–VI	88.0%	99.1%	99.8%	61.9%	89.8%
Kimetal [16]	IV–VI	89.8%	87.4%	97.5%	61.2%	89.5%

According to our study, the area under the ROC curve (AUC) for the Bethesda system was 0.842, while that for the TIRADS is 0.791. This suggests that cytology is a better predictor of malignancy than ultrasonography. Similar results were observed by Hess et al., where the AUC for TIRADS was 0.66 and for Bethesda was 0.83. However, Gokulakrishnan P et al. and Wu et al. achieved higher AUC values for TIRADS (0.932 and 0.861, respectively) than BIRADS.

CONCLUSION

A comprehensive approach to thyroid nodule evaluation, including history, clinical examination, thyroid function test, radiology, and cytology is needed to ensure accurate diagnosis and management. Based on our study, it has been found that having a higher score in TIRADS and Bethesda is associated with an increased risk of malignancy. Among the various categories in Bethesda, the best diagnostic performance was observed in Bethesda II. Additionally, it has been observed that Fine Needle Aspiration Cytology (FNAC) is a better predictor for malignancy than Ultrasound.

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