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Original Research Article

Diagnostic performance of ACR TI-RADS in solitary thyroid nodule: a comparative study with FNAC in a tertiary care hospital in Bangladesh

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ABSTRACT

Background: Thyroid nodules are highly prevalent in iodine-deficient regions in Bangladesh. The American college of radiology thyroid imaging reporting and data system (ACR TI-RADS) offers a standardized, non-invasive ultrasound-based risk stratification tool. This study evaluates its diagnostic accuracy against Fine Needle Aspiration Cytology (FNAC), the gold standard.
Methods: This cross-sectional study was conducted from April 2025 to March 2026 at BIRDEM General Hospital, Dhaka. A total of 85 adult patients (≥18 years) with solitary thyroid nodule underwent high-resolution USG for ACR TI-RADS grading, followed by USG-guided FNAC (Bethesda classification). Diagnostic accuracy metrics sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy and area under the curve (AUC) were calculated using FNAC as the reference standard.
Results: Among 85 participants, females constituted 81.2% with a male-to-female ratio of 1:4.3. The mean age was 43.6±11.8 years. ACR TI-RADS distribution: TR2 (19.0%), TR3 (35.3%), TR4 (27.0%), TR5 (18.7%). FNAC revealed suspicious for follicular neoplasm (2.4%) and non-diagnostic (3.5%). Using TR≥4 as the cut-off for malignancy (n=82 after excluding non-diagnostic cases), ACR TI-RADS demonstrated: sensitivity 85.7%, specificity 80.88%, PPV 48.00%, NPV 96.49%, accuracy 81.71%, positive likelihood ratio (LR+) 4.48, negative likelihood ratio (LR−) 0.18 and AUC 0.862 ($p<0.001$).
Conclusions: ACR TI-RADS exhibits excellent negative predictive value (96.49%) and a strong negative likelihood ratio (0.18), confirming its high reliability as a rule-out test for malignancy in solitary thyroid nodule. Low-risk (TR1–3) nodules can be safely managed with sonographic surveillance, while high-risk (TR4–5) nodules warrant FNAC confirmation.

Keywords: ACR TI-RADS, Bethesda system, Bangladesh, Diagnostic accuracy, FNAC, Thyroid nodule

INTRODUCTION

A thyroid nodule is defined as a focal, well-defined region of altered echogenicity within the thyroid gland that can be distinguished radiologically from the surrounding normal parenchyma.[1] High-resolution ultrasonography (USG) is the preferred imaging modality, with a sensitivity of 95% for detecting nodules as small as 1–3 mm.[2] Thyroid nodules are extremely common in adults, particularly in women. While only 4–7% are detected on clinical examination, the prevalence rises to as high as 67% with routine USG use. The majority (93–97%) are benign, with malignancy rates of 3–7%, primarily in patients under 20 or over 60 years.[3] Bangladesh remains endemic for thyroid disease, with a nationwide prevalence of 10–15%, reaching 21–30% in districts like Rangpur and Jamalpur.[4] FNAC is the invasive gold standard for distinguishing benign from malignant nodules. However, the ACR TI-RADS, introduced in 2017, standardizes USG reporting.[5]

Horvath et al, (2017) reported a cancer risk of 0%, 1.79%, 76.13% and 98.85% for TIRADS 2, 3, 4 and 5 respectively.[6] Singaporewalla et al found 83% concordance between TI-RADS and Bethesda classifications.[7] This study aims to validate ACR TI-RADS against FNAC in the Bangladeshi population.

Objectives

General objective

To evaluate the diagnostic efficacy of ACR TI-RADS for detecting malignancy in solitary thyroid nodule in comparison with FNAC.

Specific objectives

To evaluate thyroid nodules using ACR TI-RADS grading. To evaluate thyroid nodules using FNAC (Bethesda classification). To calculate the sensitivity, specificity, PPV, NPV, accuracy and likelihood ratios of ACR TI-RADS.

METHODS

Study design

The study was cross-sectional study.

Study duration

The study duration was from April 2025 to March 2026.

Study place

Department of Radiology and Imaging, BIRDEM General Hospital, Dhaka.

Study population

Adult patients (≥18 years) of both sexes referred to the department of radiology & imaging, BIRDEM General Hospital, Dhaka, with solitary thyroid nodule or USG-guided FNAC.

Sample size determination

The sample size was calculated using the specificity-based formula.[8] Based on a study by Foroughi et al showing 76.19% sensitivity and 47.54% specificity for ACR TI-RADS, with a disease prevalence of 32.67%,4 95% confidence interval (Z=1.96) and 15% precision, the calculated sample size was 62.5. The target sample was set at 85 to compensate for inadequate data, instrumental faults and other errors.

Sampling method

This was a purposive sampling.

Inclusion criteria

Adult (≥18 years) patients with solitary thyroid nodule irrespective of sex. Patients willing to give informed written consent.

Exclusion criteria

Patients with previously diagnosed thyroid cancer. Patients who failed to give informed consent or were non-cooperative. Any patient with bleeding diathesis.

Technique of USG of thyroid nodules

Informed written consent was obtained. Patients were positioned supine with necks slightly hyperextended. USG examination began with B-mode imaging using a 7.5MHz linear probe. Thyroid nodules were imaged in three planes and measured in the transverse plane. Nodules were staged according to ACR TI-RADS grade by a specialist radiologist blinded to the final diagnosis.

Technique of USG-guided FNAC of thyroid nodules

FNAC was performed after completion of ACR TI-RADS grading. Under USG guidance, FNAC was attempted with a 10 cc syringe with negative suction pressure. For cystic nodules, fluid was completely aspirated, then FNAC was attempted on residual tissue. Six to ten slides were prepared per nodule, placed in 95% alcohol and sent for cytological evaluation using the Bethesda system.[9]

Statistical analysis

Data were analyzed using appropriate statistical software. Sensitivity, specificity, PPV, NPV, accuracy, likelihood ratios (LR+=sensitivity/(1−specificity); LR−=(1−sensitivity)/specificity) and AUC were calculated using FNAC as the gold standard.

RESULTS

Table 1 shows that the majority of the participants were in the 31–40 age group (32.9%). The mean age of the participants was 43.6±11.8 with a range of 20 to 75 years. Table 2 shows that most of the study participants were female (81.2%), while only 18.8% were male. The male to female ratio was 1:4.3. Table 3 shows that most thyroid nodules were solid in composition (61.2%), isoechoic (52.9%), wider than tall in shape (83.5%), smooth marginated (72.9%) and had no echogenic foci within the nodule (69.4%).

Table 4 shows that most nodules were classified as TR3 at 35.3%. Table 5 shows that the majority of participants (78.8%) had benign cytology results. Table 6 shows the diagnostic performance of ACR TI-RADS in differentiating malignant and benign thyroid nodules based on FNAC as the gold standard. The sensitivity of ACR TI-RADS in detecting malignancy was 85.71%, indicating a strong ability to identify malignant lesions. The specificity was 80.88%, suggesting a moderate ability to correctly classify benign nodules.

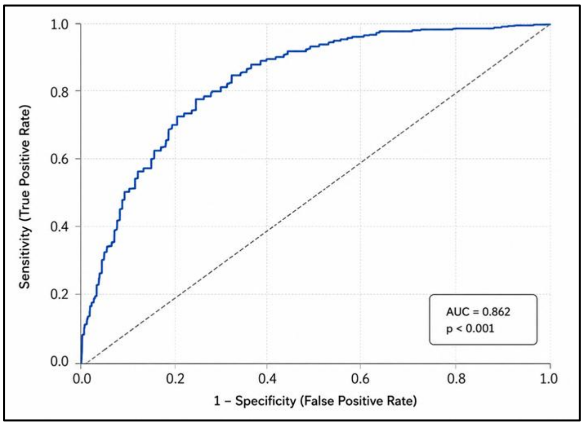


Figure 1: Receiver operating characteristic (ROC) curve of the diagnostic performance of the ACR TI-RADS grade in predicting malignant thyroid nodules (AUC=0.862, p<0.001).

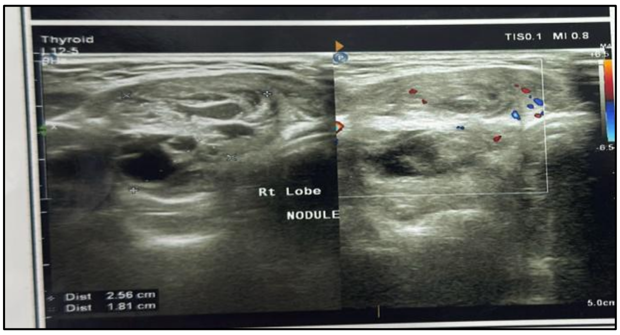
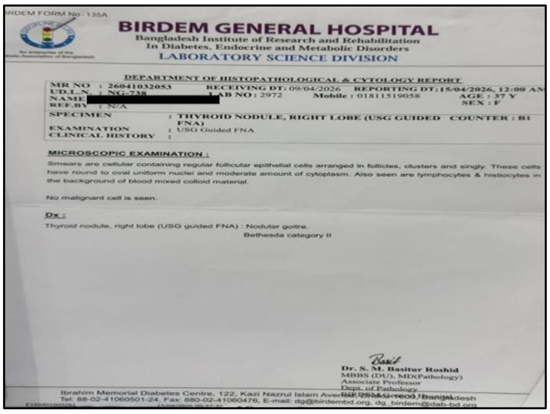


Figure 2: High-resolution USG of the thyroid gland showing a well-defined, mixed echogenic, wider than taller solitary nodule in the right lobe of the thyroid gland.



BIRDEM FORM No- 135A

BIRDEM GENERAL HOSPITAL
Bangladesh Institute of Research and Rehabilitation
In Diabetes, Endocrine and Metabolic Disorders
LABORATORY SCIENCE DIVISION

DEPARTMENT OF HISTOPATHOLOGICAL & CYTOLOGY REPORT

MR NO : 26041032053 RECEIVING DT: 09/04/2026 REPORTING DT:15/04/2026, 12:00 AM
UD.L.N. : NG-738 LAB NO : 2972 Mobile : 01811519058 AGE : 37 Y
NAME [redacted] SEX : F
REF.BY : N/A

SPECIMEN : THYROID NODULE, RIGHT LOBE (USG GUIDED FNA) COUNTER : B1
EXAMINATION : USG Guided FNA
CLINICAL HISTORY :

MICROSCOPIC EXAMINATION :

Smears are cellular containing regular follicular epithelial cells arranged in follicles, clusters and singly. These cells have round to oval uniform nuclei and moderate amount of cytoplasm. Also seen are lymphocytes & histiocytes in the background of blood mixed colloid material.

No malignant cell is seen.

Dx :

Thyroid nodule, right lobe (USG guided FNA) : Nodular goitre.
Bethesda category II

Dr. S. M. Basitur Roshid
MBBS (DU), MD(Pathology)
Associate Professor
Dept. of Pathology

Ibrahim Memorial Diabetes Centre, 122, Kazi Nazrul Islam Avenue, Dhaka-1000, Bangladesh
Tel: 88-02-41060501-24, Fax: 880-02-41060476, E-mail: dg@birdembd.org, dg_birdem@dab-bd.org

Figure 3: FNAC (histopathology) report from BIRDEM general hospital of Bethesda category ii (benign) – nodular goitre, right lobe.

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In Diabetes, Endocrine and Metabolic Disorders
LABORATORY SCIENCE DIVISION

DEPARTMENT OF HISTOPATHOLOGICAL & CYTOLOGY REPORT

MR NO : 26051010897 RECEIVING DT: 04/05/2026 REPORTING DT:09/05/2026, 12:00 AM
UD.L.N. : NG-1006 LAB NO : 3902 Mobile : 01736285365 AGE : 30 Y
NAME [redacted] SEX : F
REF.BY

SPECIMEN : THYROID NODULE, LEFT LOBE (USG GUIDED FNA) COUNTER : B1
EXAMINATION : USG Guided FNA
CLINICAL HISTORY :

ASPIRATION NOTE :

0.5cc dark brown fluid came out on aspiration

MICROSCOPIC EXAMINATION :

Smears are cellular. These reveal follicular epithelial cells arranged in follicles, clusters and singly. Some of the cells show nuclear groove and few other cells show intranuclear inclusion. Also seen are lymphocytes and histiocytes in the background of blood. However no well formed papilla is seen.

Dx :

Thyroid nodule, left lobe (USG guided FNA) : Suspicious for papillary carcinoma
Bethesda category V
Frozen section biopsy and histopathology is recommended

Dr. S. M. Basitur Roshid
Associate Professor
Dept. of Pathology
BIRDEM General Hospital

* Computer Generated Report *

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Figure 4: FNAC (histopathology) report from birdem general hospital showing bethesda category v (suspicious for papillary carcinoma), left lobe; frozen section biopsy and histopathology recommended.

Table 1: Age distribution of the study participants (n=85).

Age group (yein ars)	Frequency	(%)
20–30	20	23.5
31–40	28	32.9
41–50	15	17.7
51–60	18	21.2
61–75	4	4.7
Mean±SD	43.6±11.8	
Range	(20–75) years	

Table 2: Gender distribution of the study participants (n=85).

Gender	Frequency	(%)
Male	16	18.8
Female	69	81.2
Male:Female Ratio	1:4.3	

Table 3: Sonographic characteristics of the thyroid nodule (n=85).

Features	Frequency	(%)
Composition: Solid	52	61.2
Mixed	30	35.3
Cystic	3	3.5
Echogenicity: Isoechoic	45	52.9
Hypoechoic	26	30.6
Hyperechoic	14	16.5
Shape: Wider than tall	71	83.5
Taller than wide	14	16.5
Margin: Smooth	62	72.9
Lobulated	13	15.3
Ill-defined	7	8.2
Irregular	3	3.6
Echogenic Foci: None	59	69.4
Punctate (microcalcification)	14	16.5
Macrocalcification	10	11.8
Peripheral (rim)	2	2.3

Table 4: Distribution of the study participants by ACR TI-RADS grading at USG (n=85).

TI-RADS gradings	Frequency	(%)
TR1 (Benign)	0	0.00
TR2 (Not Suspicious)	16	19.0
TR3 (Mildly Suspicious)	30	35.3
TR4 (Moderately Suspicious)	23	27.0
TR5 (Highly Suspicious)	16	18.7
Total	85	100.0

Table 5: Distribution of study participants by FNAC (Bethesda) results (n=85).

Cytology (FNAC) findings	Frequency	(%)
Nondiagnostic/Unsatisfactory (Bethesda I)	3	3.5
Benign (Bethesda II)	67	78.8
AUS/FLUS (Bethesda III)	4	4.7
Suspicious for Follicular Neoplasm (Bethesda IV)	2	2.4
Suspicious for Malignancy (Bethesda V)	0	0.0
Malignant (Bethesda VI)	9	10.6
Total	85	100.0

Table 6: Diagnostic accuracy of ACR TI-RADS (TR ≥4 as cut-off for malignancy), excluding 3 non-diagnostic FNAC results (n=85).

ACR TI-RADS category	FNAC malignant (Bethesda IV–VI)	FNAC benign (Bethesda II)	Total
Malignant (TR4–TR5)	12 (True Positive)	13 (False Positive)	25
Benign (TR1–TR3)	2 (False Negative)	55 (True Negative)	57
Total	14	68	82

Parameter	Value	95% Confidence interval
Sensitivity	85.71%	57.19%-98.22%
Specificity	80.88%	69.53%-89.43%
Positive predictive value (PPV)	48.00%	31.34%-65.03%
Negative predictive value (NPV)	96.49%	87.48%-99.08%
Accuracy	81.71%	71.62%-89.43%
Positive likelihood ratio (LR+)	4.48	2.68 – 7.50
Negative likelihood ratio (LR−)	0.18	0.05 – 0.63
Area under the ROC curve (AUC)	0.862	0.768 – 0.956
P value	<0.001	—

DISCUSSION

This cross-sectional study evaluated the diagnostic accuracy of ACR TI-RADS in 85 patients with solitary thyroid nodule at BIRDEM General Hospital, Dhaka. The mean age of participants was 43.6±11.8 years, with the highest prevalence (32.9%) in the 31–40 age group, consistent with Rathore et al who reported 65% of their study population in the 20–40 year age group,10 and Foroughi et al who found a mean age of 49.46±13.86 years.[11]

Females constituted 81.2% of participants (male:female ratio 1:4.3), demonstrating a strong female predominance consistent with global epidemiological trends. Foroughi et al reported 87.8% female cases and Omran et al found 70% female participants.[11,12]

Solid nodule comprised 61.2% of cases, similar to Foroughi et al (68% solid) and Tuladhar et al (40% solid).[11,13] Isoechoic nodules were most common (52.9%), comparable to Hoang et al (52% isoechoic).[14] The majority of nodules were wider than tall (83.5%), aligning with Tuladhar et al (90.4%) and Pabalan and Quimbo (2024) (93.5%).[13,15] Smooth margins predominated (72.9%), consistent with Tuladhar et al (75.6%).[13] No echogenic foci were seen in 69.4% of nodules, similar to Tuladhar et al (66.9%).[13]

ACR TI-RADS distribution showed TR3 as the most common (35.3%), followed by TR4 (27.0%). This differs slightly from Tuladhar et al who reported TR3 33.0% and TR4 18.3%.[13] FNAC revealed 78.8% benign and 10.6% malignant cases, comparable to Foroughi et al (82.6% benign, 1.7% malignant) and De et al (62.04% benign, 0.72% malignant), though with a slightly higher malignancy rate due to tertiary care referral bias.[1,11]

Key diagnostic findings

The sensitivity of 85.71% indicates that ACR TI-RADS effectively identifies most malignant nodules, though slightly lower than the 90.9% reported in some studies. The specificity of 80.88% is higher than Foroughi et al (47.54%) and Hussein et al (57.6%), suggesting better performance in this cohort for correctly classifying benign nodules.[11,16]

The negative predictive value of 96.49% is outstanding, meaning that fewer than 4% of TR1–3 nodules prove malignant on FNAC. This is comparable to Dsilva et al (97.6%) and Periakaruppan et al (99.38%).[17,18] The negative likelihood ratio of 0.18 is clinically powerful: a negative (TR1–3) result reduces the post-test probability of malignancy to approximately 18% of the pre-test probability. For example, with a pre-test probability of 10%, a TR1–3 result yields a post-test probability of only ~1.8%.

The PPV of 48.0% indicates that just under half of TR4–5 nodules are actually malignant on FNAC, similar to Dsilva et al (63.5%) and Mandal et al (54.5%).[17,19] The AUC of 0.862 confirms good overall discriminatory power.

Limitations

Single-center study with a modest sample size (n=85). Purposive sampling may introduce selection bias. No TR1 nodules were identified in the sample. Histopathological correlation was not available for all nodules (FNAC only as reference). Short follow-up period for benign nodules.

CONCLUSION

This study concludes that ACR TI-RADS is a reliable non-invasive screening tool for solitary thyroid nodule. Its high NPV (96.49%) and low LR− (0.18) make it an excellent rule-out test. TR1–3 nodules can be safely monitored with serial ultrasound, while TR4–5 nodules require FNAC for definitive diagnosis. Integration of ACR TI-RADS into routine radiology practice in Bangladesh will standardize reporting, reduce unnecessary FNAC procedures and optimize clinical resource utilization.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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