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RESEARCH PAPER

Diagnostic Performance of Ultrasound Thyroid Imaging Reporting & Data System and Thyroid Scintigraphy for Detection of Malignancy in Patients with Solitary Thyroid Nodule

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Abstract

Background: Solitary thyroid nodules are common in general population; most being asymptomatic and detected only through imaging. The main clinical concern is their potential risk of malignancy because thyroid cancer incidence had significantly increased over recent decades. Ultrasonography, the preferred imaging modality provides detailed structural information. In contrast, thyroid scintigraphy categorizes nodules based on functional status. The American College of Radiology has proposed the ultrasound Thyroid Imaging Reporting and Data System (TIRADS) that enhances ultrasound's ability to stratify malignancy risk, offering a structured approach to management decisions in solitary thyroid nodules.

Objective: To compare diagnostic performance of ultrasound TIRADS and thyroid scintigraphy for detection of malignancy in patients with solitary thyroid nodule.

Methods: This cross-sectional study was carried out in the Department of Radiology and Imaging at Dhaka Medical College Hospital and the Institute of Nuclear Medicine and Allied Sciences, Dhaka, from March 2023 to February 2025. A total of 74 adult patients with solitary thyroid nodule were included in this study by non probability sampling. In all patients both ultrasound TIRADS and thyroid scintigraphy were done to evaluate the characteristics of the nodule. Patients were operated for nodule and postoperative biopsy was done for histopathology in each patient. Results of both ultrasound TIRADS and thyroid scintigraphic findings were compared with that of histopathology as gold standard to determine their (TIRADS & scintigraphy) diagnostic performance for malignancy detection with respect to sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy.

Results: The mean age of the participants was 43.5 ± 11.0 years, with a higher frequency of females (64.9%). Ultrasound TIRADS classified, 36.5% of nodules as malignant (TIRADS 4-5). Thyroid scintigraphy showed 81.1% of nodules as cold (malignant). Histopathological analysis confirmed 20.3% of nodules as malignant. TIRADS demonstrated higher sensitivity (93.3%), specificity (77.97%), PPV (51.85%), NPV (97.87%) and accuracy (81.08%) in detecting malignancy compared to thyroid scintigraphy (sensitivity 66.67%, specificity 15.25%, PPV 16.67%, NPV 64.29% and accuracy 25.68%).

Conclusion: This study demonstrates that ultrasound TIRADS is a more reliable imaging modality than thyroid scintigraphy for detection of malignancy in solitary thyroid nodules with significantly higher sensitivity, specificity, PPV, NPV and accuracy. While thyroid scintigraphy remains useful for functional assessment. Its limited specificity (15.25%) makes it ineffective for malignancy detection.

Key Words: Solitary thyroid nodule, ACR-TIRADS, thyroid scintigraphy.

Introduction

Thyroid nodule is a common clinical presentation of adult population worldwide as well as in our country. Most of them are asymptomatic and are diagnosed incidentally on imaging. The main clinical concern is their potential risk of malignancy as thyroid cancer incidence has increased fivefold in the last fifty years. An estimated 5.86 millions cases of thyroid cancer were reported in 2020.[1]

The solitary thyroid nodule may be defined as a discrete swelling within an apparently normal thyroid parenchyma. It has a higher risk of malignancy than multinodular goitre. But less than 10% solitary thyroid nodules are malignant.[2] Clinical features of a thyroid nodule are poor predictors of malignancy. As the prevalence of solitary thyroid nodule is increasing,

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ideal investigation should differentiate between benign and malignant solitary thyroid nodules to avoid unnecessary surgery for benign nodules.

High resolution neck ultrasound can provide detailed anatomical information about thyroid nodule and is capable of detecting very small lesions upto 1mm. Ultrasound categorizes nodules as cystic, solid or mixed with accuracy more than 90% and is the best method for determination of volume of the nodule.[3]

Radioactive isotope thyroid scintigraphy using Iodine-123/ Technitium-99m is done to see the functional status of the thyroid gland. This test categorizes nodules into functioning (warm or hot) or non-functioning (cold) nodules. Hot or functioning nodules are benign and cold nodules have a much higher likelihood of malignancy.[4] So, cold nodules in scintigraphy should be managed with caution.

Currently, FNAB is considered as the gold standard examination to differentiate between benign and malignant lesions.[5] Surgeons tend to treat solitary thyroid with greater degree of suspicion with the need of surgery which is based on FNAC / histopathology. However, considering the invasive nature of the test, unnecessary patients anxiety and economical burden, it is impractical to do biopsy of all patients with solitary thyroid nodule.[6]

To standardize the risk stratification for thyroid nodules, the Thyroid Imaging Reporting and Data System was first introduced in 2009.[7] The complete ACR-TIRADS (Thyroid Imaging Reporting and Data System) was released in 2017, proposed by American College of Radiology (ACR). In this system, points are given for the composition, echogenecity, shape, margin and echogenic foci of a nodule. Points in five categories are added together to determine a risk level from TR1 to TR5. Further work up is based on the nodule's ACR-TIRADS status. According to previous studies, USG TIRADS level 4 and 5 nodules were significantly associated with malignancy.[8]

This study was done to compare between two imaging modalities (ultrasound and thyroid scintigraphy) for evaluation of a solitary thyroid nodule taking reference the results of histopathology as gold standard. The purpose of the study was to find out an effective screening test for detection of malignancy in solitary thyroid nodule to reduce unnecessary biopsies and interventions.

Materials & Methods

This cross-sectional study was conducted at the Department of Radiology and Imaging, Dhaka Medical College and Hospital in collaboration with Institute of Nuclear Medicine and Allied Sciences, Dhaka from March 2023 to February 2025. Before commencement of the study, ethical approval was taken from ethical review committee of Dhaka Medical College and Hospital. A total of 74 adult patients, clinically suspected and sonologically diagnosed as solitary thyroid nodule were included in this study by non-probability sampling. Patients with age <18 years, multinodular goiter, previous history of thyroid surgery, histopathologically proven malignancy, pregnancy and lactation were excluded. Thyroid scintigraphy and ultrasound of thyroid gland with TIRADS leveling were done in all patients. TIRADS level 1-3 were denoted as benign and TIRADS level 4-5 were denoted as malignant. In thyroid scintigraphy, hot or functioning nodules were regarded as benign and cold nodules were regarded as malignant. All patients were treated surgically. Histopathology was done after surgery of solitary thyroid nodule. Subsequently finding of ultrasound TIRADS and thyroid scintigraphy were compared with that of histopathology. Statistical analyses were performed by SPSS version-26. Categorical variables were expressed as frequencies and percentages and continuous variables were expressed as mean and standard deviation. Diagnostic performances of two imaging modalities (ultrasound TIRADS and thyroid scintigraphy) in detecting malignancy in solitary thyroid nodules were determined compared to histopathology report as gold standard.

Results

Among 74 patients with solitary thyroid nodule, the mean age of the participants was 43.5 ± 11.0 years, with an age range of 18 to 60 years. The highest proportion of patients (33.8%) belonged to the 51-60 years age group, followed by 31-40 years (27.0%) indicating that prevalence of thyroid nodules is higher in middle aged and older population (table I).

Table I: Age distribution of the study participants (N=74)

Age group (years)	Frequency	Percentage
18-20	1	1.4
21-30	9	12.2
31-40	20	27.0
41-50	19	25.7
51-64	25	33.8
Mean±SD, Range (min-max)	43.5±11.0 (18-60)	
Total	74	100.0

The pie diagram illustrates that out of 74 individuals, 48 (64.9%) were female, while 26 (35.1%) were male with a

male-to-female ratio 1:1.8; denoting that solitary thyroid nodule is more common in female population (figure 1).

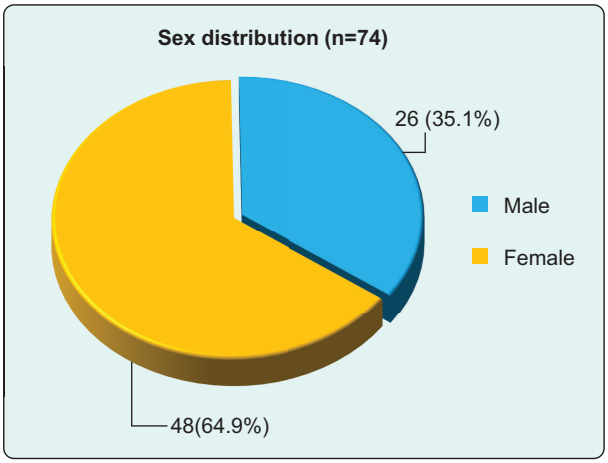


Figure-1: Pie diagram showing the sex distribution of the study subjects

Table II: Distribution of the study participants by ultrasonogram findings of thyroid (TIRADS) (N=74)

TIRADS level	Frequency	Percentage
Malignant (4-5)	27	36.5
Benign (1-3)	47	63.5
Total	74	100.0

Among the 74 study participants, 47 (63.5%) were classified as benign (TIRADS 1-3), indicating a lower likelihood of malignancy. In contrast, 27 (36.5%) of the nodules were categorized as malignant (TIRADS 4-5), suggesting a higher risk of thyroid cancer and the need for further evaluation (table II).

Table III: Distribution of study participants by thyroid scintigraphy findings (N=74)

T. Scintigraphy findings	Frequency	Percentage
Cold nodule (Malignant)	60	81.1
Functioning nodule (Benign)	14	18.9
Total	74	100.0

Among the 74 study participants, the majority (60 cases, 81.1%) were diagnosed with cold nodules, which are considered potentially malignant. In contrast, 14 cases (18.9%) were identified as functioning (hot/warm) nodules, which are generally benign and rarely associated with malignancy (table III). Of the 74 cases, 15 (20.3%) were confirmed as malignant while 59 (79.7%) were benign (table IV).

Table IV: Distribution of the study participants by histopathological findings (N=74)

Histopathological findings	Frequency	Percentage
Malignant	15	20.3
Benign	59	79.7
Total	74	100.0

Fifteen among 74 solitary thyroid nodule patients were confirmed a case of malignancy. Among 15 malignant case, ultrasound TIRADS could identify 14 as malignant case (true positive) and 1 (one) as benign (false negative). Thirteen patients were diagnosed as benign nodule by histopathology but ultrasound TIRADS considered them as malignant case (false positive). 46 cases were considered as benign nodule by both investigation (true negative) (table V). So, the diagnostic performance of ultrasound TIRADS found to be sensitivity 93.33%, Specificity 77.97%, PPV 51.85%, NPV 97.87%, Accuracy 81.08% (table V & VII)

Table V: Diagnostic Performance of TIRADS in for detecting malignancy in solitary thyroid nodule (n=74)

TIRADS	Histopathological findings		Total
	Malignant	Benign	
Malignant (4-5)	14	13	27
Benign (1-3)	1	46	47
Total	15	59	74

Among 15 malignant cases confirmed by histopathylogy, thyroid scintigraphy could identify 10 as malignant case (true positive) and 5 (five) as benign (false negative). 50 patients were diagnosed as benign nodule by histopathology but thyroid scintigraphy considered them as malignant case (false positive). About 9 cases were considered as benign nodule by

Table VI: Diagnostic performance of thyroid scintigraphy for detecting malignancy in solitary thyroid nodule (N=74)

T. Scintigraphy	Histopathological findings		Total
	Malignant	Benign	
Cold nodule (Malignant)	10	50	60
Functioning nodule (Benign)	5	9	14
Total	15	59	74

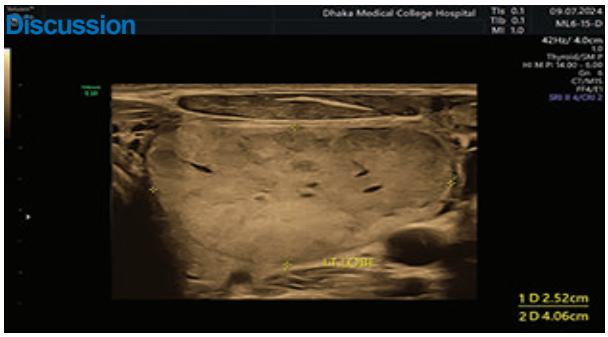
Table VII: Comparison of the diagnostic performance of ultrasound TIRADS and thyroid scintigraphy for detection of malignancy in solitary thyroid nodule (N=74).

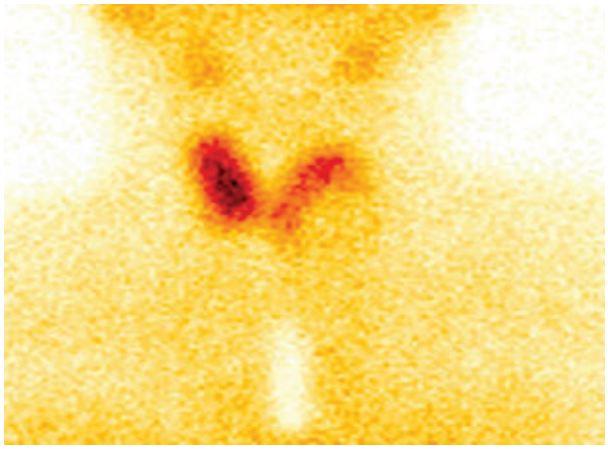
Tool	Sensitivity	Specificity	PPV	NPV	Accuracy
Ultrasound TIRADS	93.33%	77.97%	51.85%	97.87%	81.08%
T. Scintigraphy	66.67%	15.25%	16.67%	64.29%	25.68%

Sensitivity, specificity, PPV, NPV, accuracy of ultrasound TIRADS are higher in comparison to thyroid scintigraphy.

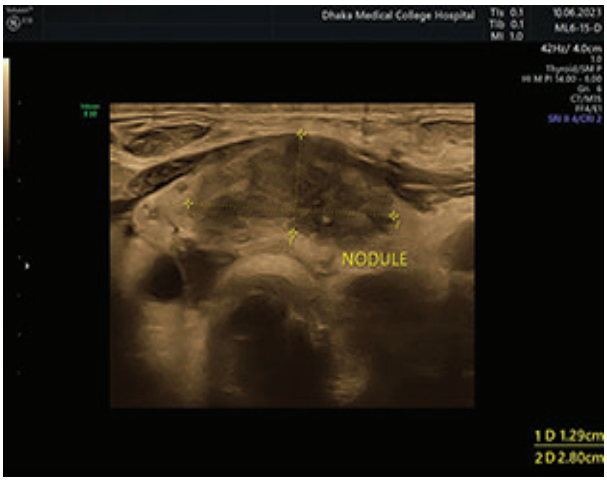
both procedure (true negative). So, the diagnostic performance of thyroid scintigraphy found to be Sensitivity 66.67%, Specificity 15.25%, PPV 16.67%, NPV 64.29%, Accuracy 25.68% (table VI & VII).

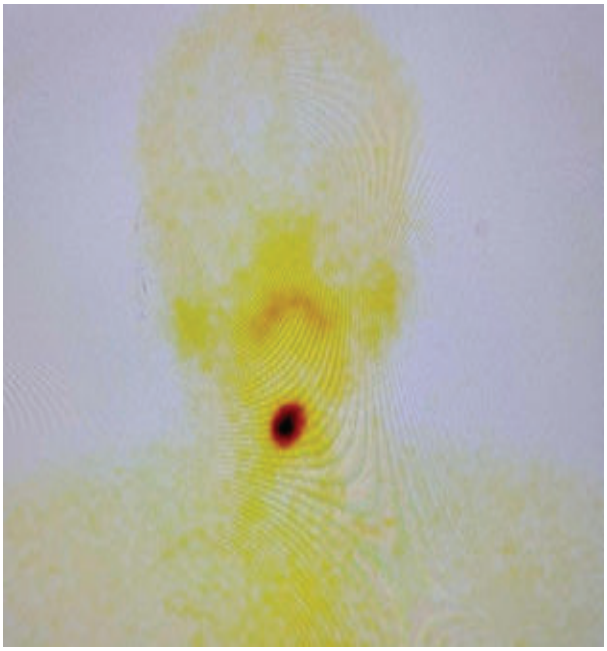
The sensitivity (93.33%) and negative predictive value (97.87%) of ultrasound TIRADS indicating strong reliability in ruling out thyroid malignancy. Specificity (77.97%) and positive predictive value (51.85%) suggest some false positives. The sensitivity of scintigraphy was 66.67%, indicating its moderate ability to detect malignant nodules. However, the specificity was low (15.25%), suggesting a high rate of false positives. So, thyroid scintigraphy lacks specificity and accuracy in malignancy detection in solitary thyroid nodule (table VII).



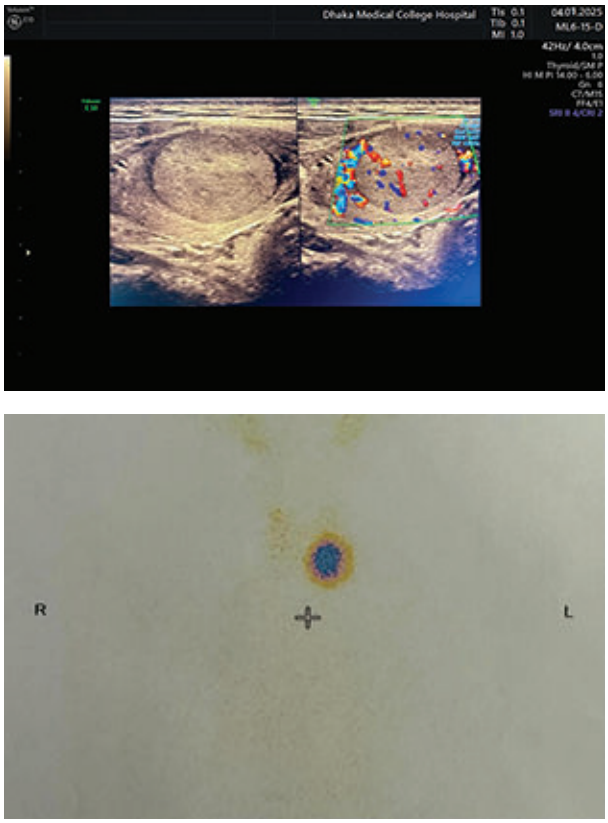


Photograph 1: Ultrasound image showing a solid, predominantly hypoechoic nodule at left lobe of thyroid gland; ultrasound TIRADS level 4. Thyroid scintigraphy image showing cold nodule. Histopathological diagnosis was follicular carcinoma.

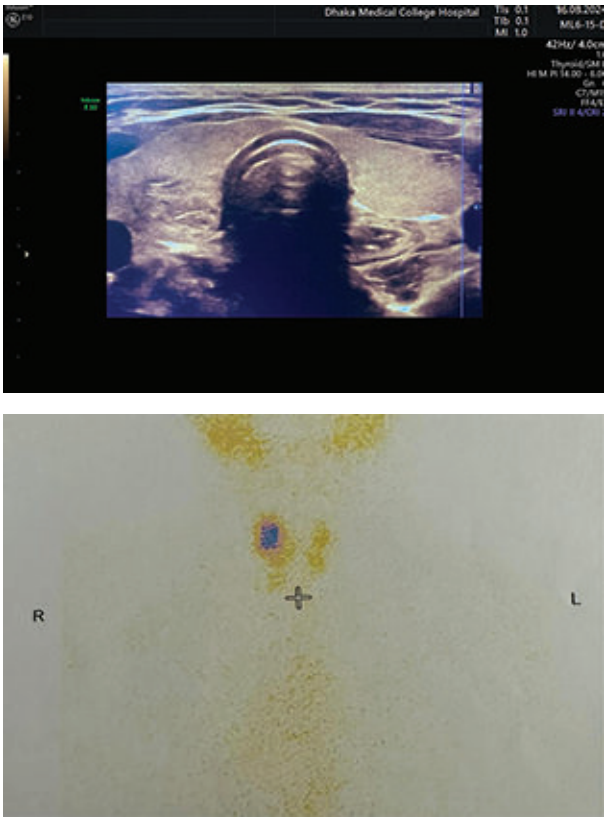




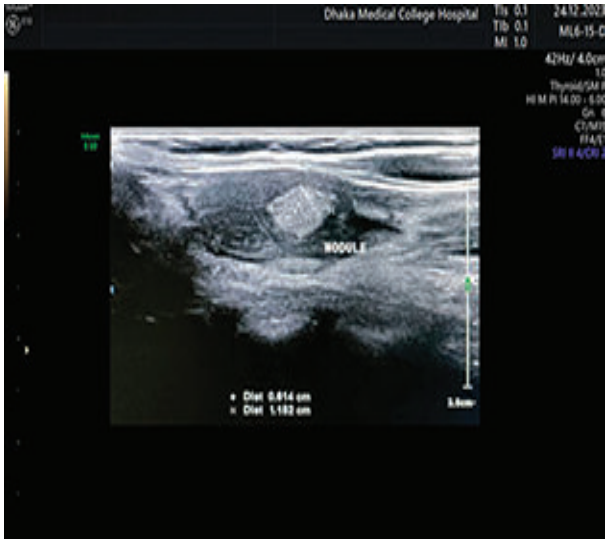
Photograph 2: Ultrasound image showing a solid, hypoechoic nodule at isthmus of thyroid gland with ill- defined margin; ultrasound TIRADS level 4. Thyroid scintigraphy image showing hot nodule. Histopathological diagnosis was papillary thyroid carcinoma.

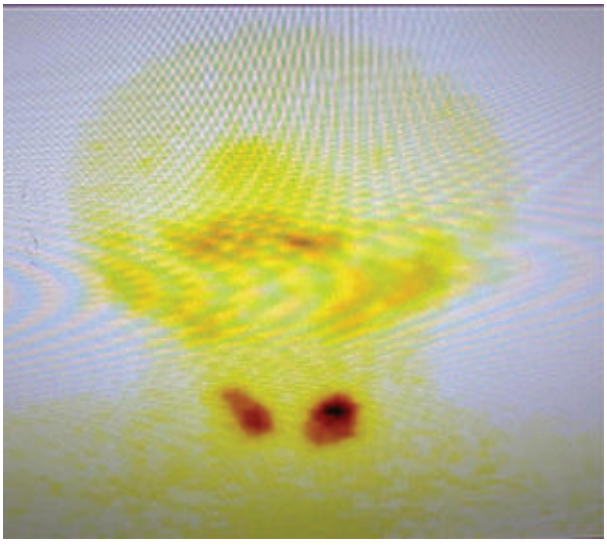


Photograph 3: Ultrasound image showing a solid, isoechoic, wider than taller nodule at left lobe of thyroid gland with smooth margin; ultrasound TIRADS level 3. Thyroid scintigraphy image showing hot nodule. Histopathological diagnosis was follicular adenoma.



Photograph 4: Ultrasound image showing a solid, isoechoic, wider than taller nodule at right lobe of thyroid gland with ill-defined margin; ultrasound TIRADS level 3. Thyroid scintigraphy image showing hot nodule. Histopathological diagnosis was follicular adenoma.





Photograph 5: Ultrasound image showing a solid, hyperechoic, wider than taller nodule at left lobe of thyroid gland with smooth margin; ultrasound TIRADS level 3. Thyroid scintigraphy image showing hot nodule. Histopathological diagnosis was hyperplastic nodule.

This cross-sectional study was conducted with an aim to find out an effective screening tool for detection of malignancy in solitary thyroid nodule. A total of 74 patients were enrolled in this study.

In the present study, the mean age of patients with solitary thyroid nodules was 43.5±11.0 years with an age range of 18 to 64 years. Similarly, Khan et al. found a mean age of 42±13.6 years (9). Isse et al. reported a mean age of 41±13 years, supporting that thyroid nodules are predominantly found in middle aged and older adults,[10] likely due to cumulative hormonal influences, iodine intake variations, and genetic predispositions.

In this study, female patients accounted for 64.9% of cases with a male-to-female ratio of 1:1.8. Adhithiya et al. reported a female predominance of 85.1% (11). Salah and Debanu et al. further supported these findings, attributing the higher prevalence in women due to hormonal influences, particularly estrogen, which plays a role in thyroid cell proliferation and nodule formation.[12,13]

In this study, TIRADS classification identified 36.5% of thyroid nodules as malignant (TIRADS 4-5) and 63.5% as benign (TIRADS 1-3). Hussein et al. (14) reported 36.0% of nodules as TIRADS 4 and 11.7% as TIRADS 5, which together account for 47.7% of nodules with moderate to high suspicion of malignancy, slightly higher than the present study. Khan et al. documented that TIRADS 1-3 nodules constituted 83.1% of cases,[9] which is higher than our study, indicating a possible variation in patient demographics and selection criteria.

In present study, thyroid scintigraphy findings revealed 81.1% cold nodules and 18.9% were functioning nodules. Aleem and Haytham reported a similar prevalence of cold nodules supporting the need for further evaluation in these cases.[8]

In current study, the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and overall accuracy of TIRADS in detecting malignancy were 93.33%, 77.97%, 51.85%, 97.87% and 81.08% respectively, indicating a high ability of TIRADS to rule out malignancy. Aleem and Haytham reported a 100% sensitivity, 79.2% specificity, 54.5% PPV, 100% NPV and an accuracy of TIRADS about 83.3%, further reinforcing the effectiveness of TIRADS in risk stratification.[8]

In this study, the diagnostic performance of thyroid scintigraphy revealed 66.67% sensitivity, 15.25% specificity, 16.67% positive predictive value (PPV), 64.29% negative predictive value (NPV) and overall accuracy of 25.68%. Aleem and Haytham reported 66.7% sensitivity, 16.7% specificity, 20% PPV, 66.7% NPV of thyroid scintigraphy and accuracy of 26.7% (8), closely matching with present study. These findings confirm that while thyroid scintigraphy is useful for assessing the functional status of nodules, it lacks sufficient specificity for reliably differentiating benign from malignant lesions. These findings strengthen the current shift toward ultrasound-based risk stratification systems such as TIRADS as the preferred imaging modality for thyroid nodule evaluation.

Conclusion

This study demonstrates that ultrasound TIRADS is a more reliable imaging modality than thyroid scintigraphy for detection of malignancy in solitary thyroid nodules with significantly higher sensitivity, specificity, PPV, NPV and accuracy. While thyroid scintigraphy remains useful for functional assessment; its limited specificity (15.25%) makes it less ineffective for malignancy detection.

Recommendation

Ultrasound TIRADS might be used primarily for solitary thyroid nodule evaluation to ensure effective patient's management and to reduce unnecessary interventions; while scintigraphy should be used selectively, particularly in cases where functional status influences clinical management.

Conflict of Interest: There are no conflicts of interest.

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