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RESEARCH ARTICLE

A Retrospective Study Correlating Ultrasound Based Thyroid Imaging Reporting and Data System (TIRADS) with Bethesda System for Thyroid Cytopathology in Thyroid Nodule Risk Stratification

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Abstract:

Objective:

To evaluate the efficacy of the ultrasound-based Thyroid Imaging Reporting and Data System (TIRADS) in estimating the risk of malignancy in thyroid nodules by correlating it with the Bethesda system of thyroid cytopathology.

Methods:

A retrospective single-center study was conducted in a specialty hospital in UAE from November 2017 to November 2019 on 259 thyroid nodules that underwent ultrasound and fine-needle aspiration cytology (FNAC). Thyroid nodules were evaluated using American College of Radiology (ACR) TIRADS and categorized as benign (TR1), not suspicious (TR2), mildly suspicious (TR3), moderately suspicious (TR4), or highly suspicious (TR5) for malignancy. The risk of malignancy associated with each TIRADS category was evaluated by comparing it with the Bethesda classification system of cytopathology.

Results:

Ultrasound and FNAC data of 259 nodules were reviewed. Out of these, 33 (12.7%) nodules were excluded because FNAC revealed atypia of undetermined significance or follicular lesion of undetermined significance. The estimated risk of malignancy in TR 3 was 13.6%, TR4 was 27%, and TR5 was 63.6%. There was a statistically significant correlation between TIRADS and Bethesda system, which was determined using the Chi-square test ($p < 0.001$). The receiver operating curve (ROC) analysis revealed specificity of 81.3% [95% CI, 74.9 - 86.6%], NPV of 91% [95% CI, 87.1 - 93.8%] and accuracy of 77.9% [95% CI, 71.9 - 83.1%], when differentiating benign from malignant nodules.

Conclusion:

The ultrasound-based ACR-TIRADS scoring correlates well with the Bethesda cytopathology in thyroid nodule risk stratification. Thus, it can be used as a simple and effective tool to decide further management and avoid unnecessary FNAC and surgeries in thyroid nodules.

Keywords: Thyroid nodule, Biopsy, Fine-needle, Cytodiagnosis, Ultrasonography, Risk assessment, Thyroid Imaging Reporting and Data System, Bethesda.

Article History

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1. INTRODUCTION

The nodular disease of thyroid is highly prevalent and frequently discovered in clinical practice either during a physical examination or various imaging procedures. The detection rate of thyroid nodules by palpation is 5 to 10%, and

by high resolution ultrasound is 19 to 68%. The nodules affect more women than men [1].

Increased diagnosis of thyroid nodules is due to the widespread use of modern imaging modalities, particularly ultrasound (US). Some of the other imaging modalities are Computed Tomography (CT), Magnetic Resonance Imaging (MRI), and Positron Emission Tomography (PET) [2].

Although the majority of thyroid nodules are benign,

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differentiating malignant from benign thyroid lesions is still the most challenging dilemma for clinicians. In the past few decades incidence of thyroid cancer has significantly increased [3]. The prevalence of malignancy rate in thyroid nodule is 5%, even though rates as high as 15% have been reported [4 - 6].

Despite a rapid increase in the reported incidence of papillary thyroid cancer that were reported from screening thyroid sonography in asymptomatic patients in South Korea, mortality has remained extremely low [7]. In the United States, overdiagnosis of thyroid cancer, defined as “diagnosis of thyroid tumours that would not, if left alone, result in symptoms or death” accounted for 70% to 80% of thyroid cancer cases in women and 45% of cases in men between 2003 and 2007 [8]. It is controversial whether or not such a benefit exists in thyroid nodule evaluation [9, 10].

High-resolution ultrasound of the thyroid is recommended as the first-line modality in the evaluation of thyroid nodules [11], and therefore, a reliable, non-invasive ultrasound-based stratification method to identify which nodules require FNA based on a reasonable likelihood of biologically significant malignancy is highly desirable. Thyroid Image Reporting and Data System (TIRADS) classification system proposed by ACR, which is similar to Breast Imaging Reporting and Data System (BIRADS) for breast lesion, is one such method which is most useful that reduces interobserver variability and also provides a uniform effective communication system. The TIRADS risk stratification system is designed to identify the most clinically significant malignancies while reducing the number of biopsies performed on benign nodules [12].

The purpose of this study was to evaluate the efficacy of ultrasound-based TIRADS in thyroid nodule risk stratification by correlating it with Bethesda system for thyroid cytopathology.

2. MATERIALS AND METHODS

Institutional Review Board approval of NMC specialty hospital (UAE) research ethics committee was obtained for this retrospective single-center study, and the requirement for informed consent was waived. Records of all patients from November 2017 to November 2019 with thyroid nodule for which ultrasound-guided FNAC was performed and cytopathology results available were retrieved from the medical record for review.

Inclusion criteria: All cases of thyroid nodules that underwent FNAC following a complete thyroid ultrasound whose cytopathology report was available were included in this study.

Exclusion criteria: All cases whose ultrasound images were not available in the PACS, nodules with indeterminate cytology, known cases of thyroid cancer, and post-operative thyroid were excluded from the study.

2.1. Ultrasound Imaging and Analysis

All thyroid ultrasound was performed on Philips IU22 or Supersonic ultrasound machine equipped with a 5 to 12 MHz linear array probe. The scanning protocol in all cases included both transverse and longitudinal images of the thyroid nodule. Ultrasound images were retrospectively reviewed by 2

experienced radiologists who had more than 10 years' experience with thyroid ultrasound, blinded to patient clinical details and pathology report. Thyroid nodules were evaluated using an axial image, longitudinal image, and also the cine video clips stored in PACS so that a comprehensive assessment could be made without any loss of information. In case of any inconsistency, findings were mutually discussed until an agreement was reached.

All thyroid nodules were evaluated using the 2017 ACR TIRADS assessment category [12]. Thyroid nodules were characterized according to composition, echogenicity, shape, margin, and echogenic foci. The ultrasound features in the ACR TIRADS were categorized as benign (TR1), not suspicious (TR2), mildly suspicious (TR3), moderately suspicious (TR4), or highly suspicious (TR5) for malignancy. Points were given for all the ultrasound features in a nodule, with more suspicious features being awarded additional points. Fig. (1) presents these features arranged as per the five lexicon categories.

When assessing a nodule, the reader-selected one feature from each of the first four categories and all the features that apply from the final category. The features from all the categories were then added to derive the final points. The total points determine the nodule's ACR TIRADS level, which ranges from TR1 (benign) to TR5 (high suspicion of malignancy) with TR1 indicating 0 points; TR2, 2 points; TR3, 3 points; TR4, 4 - 6 points; and TR5, 7 or more points (Fig. 2).

It should be noted that no combination of findings resulted in a total of 1 point. As per the guidelines of the ACR TIRADS committee, if composition, echogenicity, or margins could not be determined for any reason, they were allocated 2, 1, or 0 points, respectively.

2.2. Ultrasound-guided FNAC

FNA of the thyroid nodule was performed by a surgeon under ultrasound guidance, which was provided by the radiologist. The thyroid nodule being evaluated was matched with the thyroid nodule whose FNAC was performed by using the stored axial images, longitudinal images, and the cine video clips to get a better spatial orientation. The echogenic tip of the FNAC needle within the nodule was also looked for ascertaining that the sample represented the true content of the nodule. FNA was performed using a 23-gauge needle attached to a 10-cc syringe. Upon aspiration, negative pressure was maintained until blood appeared in the hub of the syringe. The aspirated material was rinsed in a cytofixative solution. An experienced cytopathologist specializing in thyroid pathology interpreted the findings. Pathologists studied all of the slides, considering the following elements: cellularity (score 0 to 4), colloid (score 0 to 4), lymphocytes/plasma cells (score 0 to 4), and macrophages (score 0 to 4). Minimally 5 groups of 10 thyroid native cells were considered as sufficient (informative) and less cellularity as insufficient (non-informative). The results were categorized as Nondiagnostic or unsatisfactory (Category 1), Benign (Category 2), Atypia of undetermined significance (AUS) or follicular lesion of undetermined significance (FLUS) (Category 3), Follicular neoplasm or suspicious for a follicular neoplasm (Category 4), Suspicious for malignancy (Category 5) and Malignant (Category 5) [13].

2.3. Statistical Method

Data for the study was collected in a standardized excel sheet from the Picture Archiving and Communication System (PACS) and the Hospital Information System (HIS).

Data collected was reported as the mean ± Standard Deviation (SD) values, or as the median with percentiles between 25 and 75 (continuous variables), or as frequencies and percentages (categorical variables). Classification data was

compared using the chi-square test or the Fisher exact test. The cutoff values were obtained from the ROC analyses, and the corresponding sensitivity (SEN), specificity (SPE), positive predictive value (PPV), negative predictive value (NPV), and accuracy (ACC) were calculated. P values < 0.05 was considered for statistical significance. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY.

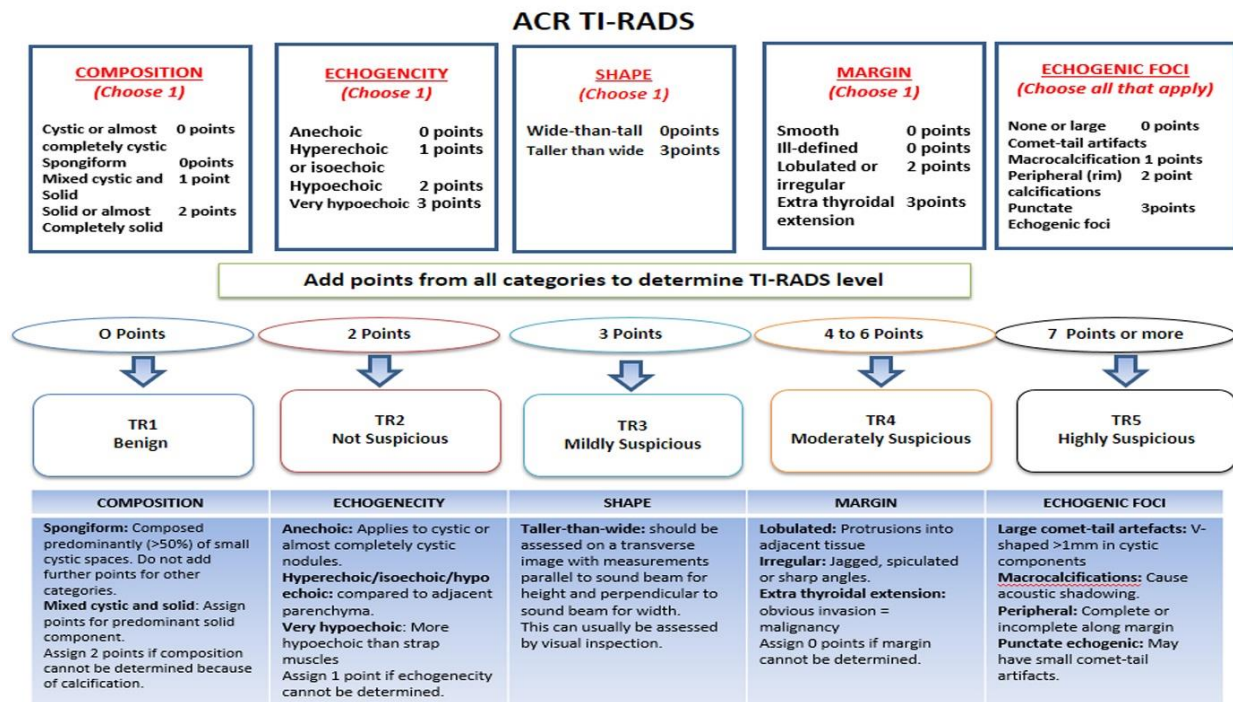


Fig. (1). Five categories on the basis of the ACR Thyroid Imaging, Reporting and Data System (TI-RADS) lexicon, TR levels; Explanatory notes at the bottom.

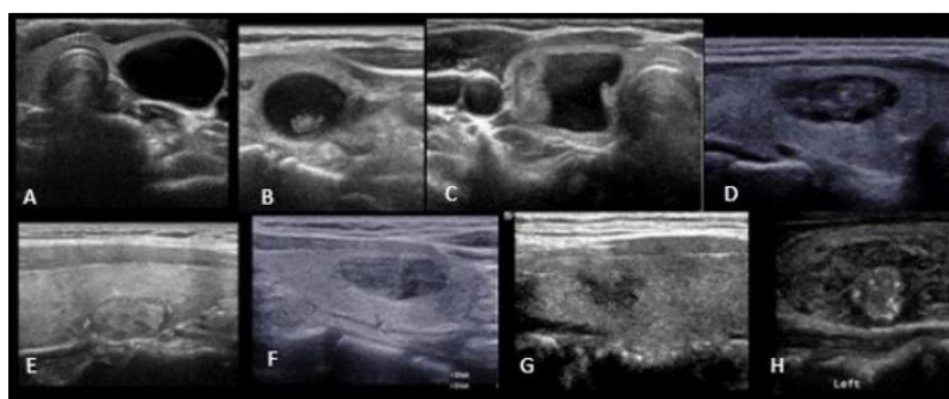


Fig. (2). Representative images of TI-RADS in thyroid nodules; A: Cystic nodule, anechoic, wider than tall shape, smooth margin, no echogenic foci (0 points), TR1; B & C: are mixed cystic and solid nodule, wider than tall shape, smooth margin, no echogenic foci (2 points), TR2; D: Spongiform nodule, hyperechoic, wider than tall, smooth margin, no echogenic foci (1 point), TR2; E: Solid, hyperechoic, wider than tall shape, smooth margin, and no echogenic foci (3 points), TR3; F: Solid, hypoechoic, wider than tall shape, smooth margin, and no echogenic foci (4 points), TR4; G: Solid, hypoechoic, wider than tall shape, irregular margin, and no echogenic foci (6 points), TR4; H: Solid, hyperechoic, taller than wide, smooth margin, punctate echogenic foci (9 points), TR5.

3. RESULTS

The study included an evaluation of 259 thyroid nodules (in 259 patients), out of which 51 (19.7%) patients were male, and 208 (80.3%) patients were female. The patient's age group was from 22 to 67 years (mean 41 years). The mean nodule size was 2.3 (±1.37) cm.

Ultrasound and FNAC data for 259 nodules were reviewed in the study. Out of these, 33 (12.7%) nodules were excluded because FNAC revealed atypia of undetermined significance or follicular lesion of undetermined significance (Bethesda 3). Out of the 226 nodules that underwent FNAC, 4 (1.8%) were classified as TR1, 53 (23.5%) were TR2, 110 (48.7%) were TR3, 37 (16.4%) were TR 4 and 22 (9.7%) were TR 5. Most of the thyroid nodules were in the TR2 and TR3 category based on ultrasound evaluation, which accounted for 163 (72.1%), TR2: 53, and TR3: 110) out of 226 nodules. Similarly, most of the nodules turned out to be Bethesda 2 on FNA, which accounted for 170 (75.2%) out of 226. Table 1 shows the joint distribution between TIRADS and Bethesda classification, which was statistically significant ($p < 0.001$).

The nodules classified as Bethesda 2 were considered benign, and the nodules classified as Bethesda 4 to 6 were considered malignant. Bethesda 1 was grouped under benign category only when the repeated FNA was also classified under Bethesda 1 and /or stability of the nodule was demonstrated over a six-month ultrasound follow up. There were 17 such Bethesda nodules that met this criteria. Table 2 shows the risk of malignancy in thyroid nodules based on TIRADS classification system, which was statistically significant ($p < 0.001$).

In our study 53 (23.4%) nodules were classified as TR2 on ultrasound. Out of these, none turned out to be Bethesda 4 or

higher, which means that none were malignant.

Out of 110 (48.7%) nodules classified as TR 3 on ultrasound, 4 (3.6%) were Bethesda 1, 91 (82.7%) nodules were in Bethesda 2, and 15 (13.6%) nodules were in Bethesda 4 to 6 category. Out of 37 (16.4%) nodules classified as TR4 on ultrasound, 9 (24.3%) were Bethesda 1, 18 (48.6%) nodules were in Bethesda 2, and 10 (27.0%) nodules were in Bethesda 4 to 6 categories. Around 22 (9.7%) nodules were classified as TR5, out of which 1 (4.5%) was Bethesda 1, 7 (32%) nodules were in Bethesda 2, and 14 (63.6%) nodules were in Bethesda 4 to 6 category.

There were 35 out 59 (59.3%) nodules that appeared suspicious on ultrasound, classified under TR4 and TR5 but turned out to be benign. Considering all the nodules, the proportion of malignant nodules classified as TR2 is 0%, as TR3 is 13.6%, as TR4 is 27.0% and as TR5 is 63.6%. The ratio of benign to malignant nodule was 1 in 5 in our study.

We calculated sensitivity, specificity, negative predictive value (NPV), positive predictive value (PPV), and accuracy based on cytopathology results. TR scores 4 and 5 were considered positive for malignancy, and TR scores 1–3 were considered negative for malignancy. Cross-tabulation of TIRADS and Bethesda was also performed.

There was a significant association between TIRADS and the Bethesda system of classification ($p < 0.001$) determined by the Chi-square test. The study revealed sensitivity of 61.5% [95% CI, 44.6 – 76.6%], specificity of 81.3% [95% CI, 74.9 – 86.6%], PPV of 40.7% [95% CI, 31.7 – 50.2%], NPV of 91% [95% CI, 87.1 – 93.8%] and accuracy of 77.9% [95% CI, 71.9 – 83.1%] in differentiating benign from malignant nodules. The area under the curve was 0.714 in the receiver operating characteristic (ROC) curve, which indicated that the results were fair (Fig. 3).

Table 1. Thyroid imaging reporting and data system and Bethesda correlation.

US - TR Category	BETHESDA 1	BETHESDA 2	BETHESDA 4	BETHESDA 5	BETHESDA 6	Total
TR1 - Benign	0	4	0	0	0	4
TR2 - Not Suspicious	3	50	0	0	0	53
TR3 - Mildly Suspicious	4	91	8	6	1	110
TR4 - Moderately Suspicious	9	18	5	2	3	37
TR5 - Highly Suspicious	1	7	2	4	8	22
Total	17	170	15	12	12	226

Table 2. Risk of malignancy for all nodules classified by thyroid imaging reporting and data system.

US - TR Category	FNAC		Total	Risk of Malignancy	
	Benign	Malignant			
TR1 - Benign	Count	4	0	4	0%
TR2 - Not Suspicious	Count	53	0	53	0%
TR3 - Mildly Suspicious	Count	95	15	110	13.6%
TR4 - Moderately Suspicious	Count	27	10	37	27%
TR5 - Highly Suspicious	Count	8	14	22	63.6%
	Total	Count	187	39	226
% of Total		82.7%	17.3%	100.0%	-

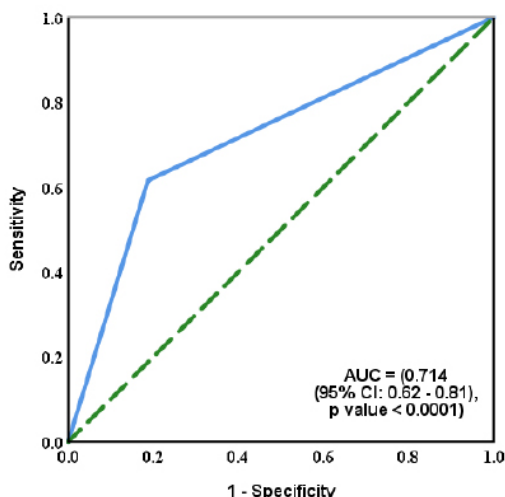


Fig. (3). (ROC): Accuracy is measured by the area under the ROC curve. 0.90 - 1.00 = very good (A); 0.80 - 0.90 = good (B); 0.70 - 0.80 = fair (C); 0.60 - 0.70 = poor (D); 0.50 - 0.60 = fail (F).

Table 3. Comparative chart showing the risk of malignancy in thyroid nodule using several reporting systems.

-	TIRADS 1	TIRADS 2	TIRADS 3	TIRADS 4	TIRADS 5
Horvath <i>et al.</i> (2009)	0%	0%	14.1%	45.1%	89.6%
Kwak <i>et al.</i> (2011)	-	0%	1.7%	3.3 to 72.4%	87.5%
Kwak <i>et al.</i> (2013)	-	-	7.3%	8.3 to 96.6%	
Moifo <i>et al.</i> (2013)	-	0%	2.2%	5.9 to 57.9%	100%
Russ <i>et al.</i> (2013)	0%	0%	0.25 to 6%	69%	100%
Middleton <i>et al.</i> (2017) (using ACR TIRADS)	0.3%	1.5%	4.8%	9.1%	35%
Periakaruppan G. <i>et al.</i> in (2018) (using ACR TIRADS)	-	0%	2.2%	38.5%	77.8%
Koseoglu Atilla (2018) (using ACR TIRADS)	-	TR 2 less than 25 mm, 1.2%	TR3 less than 25 mm is 1.2% and more than 25 mm is 1.8% Bethesda IV-VI	6.8%	28.6%
Modi L. (2020) (using ACR TIRADS)	-	0% Bethesda category VI	-	-	21.5% Bethesda category VI
Our Study (using ACR TIRADS)	0%	0%	13.6%	27%	63.6%

The diagnostic performance of ultrasound-based TIRADS for the evaluation of the risk of malignancy when compared with the Bethesda cytopathology system for TR2, TR3, TR4, and TR5 was 0%, 13.6%, 27%, and 63.6%, respectively. Table 3 shows our study results, comparing them with other studies. The risk of malignancy for patients classified as TIRADS 4 was estimated at 1.9 times the risk for those rated as TIRADS 3. The risk of malignancy for patients classified as TR 5 was estimated at 4.6 times the risk for those rated as TR3.

4. DISCUSSION

The widespread use of imaging has resulted in an overwhelming increase in recognition of thyroid nodules. FNAC is the best tool for deciding whether thyroid nodules require surgery or follow up. Hence, there is a need to establish some ultrasound criteria to select nodules for FNAC to maximize benefit and minimize cost. Since 2009, many studies have proven the usefulness of ultrasound imaging to help in

this selection and differentiate benign from malignant nodules [14 - 23]. Most of them are complex, with several ultrasound features that are time-consuming and difficult to use in daily clinical practice. Some of them also have a low correlation between ultrasound features and FNAC results [24]. Therefore, a reliable, non-invasive method to identify which nodules warrant FNAC based on a reasonable likelihood of biologically significant malignancy would be highly desirable. In 2012, the ACR convened committees to (a) provide recommendations for reporting incidental thyroid nodules, (b) develop a set of standard terms (lexicon) for ultrasound reporting, and (c) propose a TIRADS based on the lexicon. In 2015 and then subsequently in 2017, the white paper of ACR TIRADS Committee came out with the recommendations providing guidance regarding the management of thyroid nodules based on their ultrasound appearance. Of all the systems, the ultrasound-based classification proposed by ACR TI-RADS Committee is considered to be simple, reproducible, and similar to BIRADS system, which has been in use for many

years and is familiar to most radiologists [12].

Therefore, we aimed to assess the efficacy of the ultrasound-based ACR TIRADS classification system to evaluate the risk of malignancy in thyroid nodules by comparing it with the results of the Bethesda Cytopathology grading system. We have also compared our results with other studies and classification systems.

In this study, we evaluated thyroid nodules based on composition, echogenicity, shape, margin, and echogenic foci to evaluate the TIRADS score. We found that TR 1 and 2 have 0% risk of malignancy. The estimated risk of malignancy in TR 3 was 13.6%, in TR 4 was 27%, and TR 5 was 63.6%. The ratio of benign to malignant FNA in our study was 5:1.

In 2009, Horvath *et al.* published the first study using TIRADS in which he classified thyroid nodules using 10 ultrasound patterns and subsequently divided them into 4 TIRADS groups [22]. The probability of a malignant FNAB in TIRADS 2, 3, 4 (4A and 4B), and 5 was 0, 14.1, 45, and 89.6%, respectively. Sensitivity, specificity, PPV, NPV, and accuracy were 88, 49, 49, 88, and 94%, respectively. This study seems simple, but it has limitations in that too many US features should be converted into these stereotypic 10 US patterns to assume their malignancy risk, which sometimes is difficult to achieve.

Kwak *et al.* in 2011 studied the risk of malignancy in thyroid nodule according to the number of suspicious US features. He showed that as the number of suspicious US features increased, the fitted probability and risk of malignancy also increased. This study described that a malignancy risk of 0% is expected for TIRADS 2, 1.7% for TIRADS 3, a risk of 3.3–72.4% for TIRADS 4, and 87.5% for TIRADS 5 [23]. The main limitation of this study was that each suspicious US feature was assumed to be the same, even though each US feature had a different probability of malignancy. Therefore, the risk of malignancy was higher in a thyroid nodule with one suspicious US feature (such as a microcalcification or microlobulated margin) than for a thyroid module with 2 suspicious malignant US features (solid composition and hypo-echogenicity).

In 2013, to overcome this shortcoming, Kwak *et al.*, in a multicentric study, suggested a new model where individual Ultrasound signs were assigned a risk score according to its odds ratio for predicting malignancy. In this study, the risk of malignancy was 7.3% for TIRADS 3 category and 8.3–96.6% for TIRADS 4 and 5 category. Unfortunately, applying this 15-point scale is far too time-consuming [24].

Moifo *et al.* in 2013 characterized nodules according to the internal component (solid, mixed, or cystic), margins, echogenicity, evidence of calcifications, and the shape [25]. Using the modified Russ classification, each nodule was classified into a TIRADS category (1, 2, 3, 4A, 4B, and 5) based on the US features. The risk of malignancy of the TIRADS categories was as follows: TIRADS 2:0%, TIRADS 3: 2.2%, TIRADS 4A: 5.9%, TIRADS 4B: 57.9%, TIRADS 5: 100% [26].

Russ *et al.* described a system that is reproducible, less cumbersome, and allows large-scale testing. The sensitivity,

specificity, and odds ratio of each Ultrasound sign was calculated, and specific vocabulary and a standardized report were established [27, 28]. A flowchart was developed to easily define the score of a particular nodule. Assessment categories corresponded to a 6-point scale: score 1 for normal, 2 for benign, 3 for very probably benign, 4A for low suspicion, 4B for high suspicion, and 5 for certainly malignant. The corresponding risk of malignancy, using this scale, was 0, 0, 0.25, 6, 69, and 100%, respectively. Specificity, negative predictive value, and accuracy of this TIRADS score were 44.7, 99.8, and 48.3%, respectively.

Middleton *et al.* in 2017 published a multi-institutional study in which he evaluated the risk stratification system used by the ACR-TIRADS. In this study TR1, TR2, TR3, TR4, and highly suspicious TR5 were associated with aggregate cancer risks of 0.3%, 1.5%, 4.8%, 9.1%, and 35.0%, respectively [29]. They also compared ACR TIRADS, the Korean Society of Thyroid Radiology (KSThR), Thyroid Imaging Reporting and Data System (TIRADS), and the American Thyroid Association guidelines using 3422 thyroid nodules for which pathological findings were available. On comparison, the ACR TIRADS system showed a higher biopsy yield of malignancy, primarily because of a reduced number of biopsies of benign nodules, thus proving that ACR TIRADS performs well when compared with other well-established guidelines [30].

Periakaruppan G. *et al.* in 2018 found the risk of malignancy for TR 2, TR 3, TR 4, and TR 5 was 0, 2.2, 38.5, and 77.8%, respectively on correlating ACR TIRADS with Bethesda System for Reporting Thyroid cytopathology [31]. Their study revealed 54.54% PPV, and 99.38% NPV. In another similar study, no TR2 or TR3 nodules were associated with malignant cytopathology, and only 21.5% of TR 5 nodules were found to be malignant [32].

Our results for evaluating the risk of malignancy using ACR TIRADS system are within range, as seen in other studies, illustrated in a tabulated format in Table 3. Risk of malignancy in our TR3 category was 13.6%, which is similar to the study of Horvath *et al.* (TR3: 14%) but slightly higher than that reported in other studies. This could be related to selection bias in our study as we retrospectively evaluated only those nodules which had undergone FNAC and left out other TR3 nodule cases during the same time who did not opt for any intervention. Different cut off size for performing FNAC in TR3 nodules in other studies could also be a potential reason for this discrepancy as our study also included TR3 nodules less than 2.5 cm for FNAC. Geographical variation also cannot be ruled out as one of the reasons for the higher rate of malignancy in TR3 nodules, and studies with a large cohort should be conducted. There was a statistically significant trend of an increased risk of malignancy from TR 3 to TR5 nodules which has been noted in other studies. None of the TR2 nodules turned out to be malignant in our study, which resonates with the findings seen in most other studies, therefore, FNA can be avoided in patients with TR 2 nodule, which contribute to the majority of newly detected cases and thereby avoiding unnecessary biopsies and surgeries.

5. LIMITATIONS

This study has limitations, which include retrospective data collection, cases with benign cytology that were not operated for ethical reasons, and lack of histopathological confirmation as the patients preferred not to get operated or go to other hospitals or their own countries to get operated.

CONCLUSION

In conclusion, ACR TIRADS scoring is a simple, applicable, and potentially cost-effective approach of classifying thyroid nodules on ultrasound, which determines the probability of malignancy with a certain level of confidence and thus helps in deciding the further management and avoiding unnecessary FNA and surgeries.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The approval of the Institutional review board of the NMC specialty hospital research ethics committee was obtained for this retrospective study (REC 05/2019). An interim and final result review was also performed by the committee.

HUMAN AND ANIMAL RIGHTS

No Animals were used in this research. All human research procedures were followed in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013.

CONSENT FOR PUBLICATION

The requirement for informed consent was waived.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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REFERENCES

- [1] Haugen BR, Alexander EK, Bible KC, *et al.* 2015 American thyroid association management guidelines for adult patients with thyroid nodules and differentiated thyroid cancer: The american thyroid association guidelines task force on thyroid nodules and differentiated thyroid cancer. *Thyroid* 2016; 26(1): 1-133. [http://dx.doi.org/10.1089/thy.2015.0020] [PMID: 26462967]
- [2] Pemayun TG. Current diagnosis and management of thyroid nodules.

- [3] Hoang JK, Lee WK, Lee M, Johnson D, Farrell S. US Features of thyroid malignancy: pearls and pitfalls. *Radiographics* 2007; 27(3): 847-60. [http://dx.doi.org/10.1148/rg.273065038] [PMID: 17495296]
- [4] Gharib H, Goellner JR. Fine-needle aspiration biopsy of the thyroid: an appraisal. *Ann Intern Med* 1993; 118(4): 282-9. [http://dx.doi.org/10.7326/0003-4819-118-4-199302150-00007] [PMID: 8420446]
- [5] Frates MC, Benson CB, Doubilet PM, *et al.* Prevalence and distribution of carcinoma in patients with solitary and multiple thyroid nodules on sonography. *J Clin Endocrinol Metab* 2006; 91(9): 3411-7. [http://dx.doi.org/10.1210/jc.2006-0690] [PMID: 16835280]
- [6] Hegedüs L. Clinical practice. The thyroid nodule. *N Engl J Med* 2004; 351(17): 1764-71. [http://dx.doi.org/10.1056/NEJMcp031436] [PMID: 15496625]
- [7] Ahn HS, Kim HJ, Welch HG. Korea's thyroid-cancer "epidemic"-screening and overdiagnosis. *N Engl J Med* 2014; 371(19): 1765-7. [http://dx.doi.org/10.1056/NEJMmp1409841] [PMID: 25372084]
- [8] Vaccarella S, Franceschi S, Bray F, Wild CP, Plummer M, Dal Maso L. Worldwide thyroid-cancer epidemic? The increasing impact of overdiagnosis. *N Engl J Med* 2016; 375(7): 614-7. [http://dx.doi.org/10.1056/NEJMmp1604412] [PMID: 27532827]
- [9] Pazaitou-Panayiotou K, Capezzone M, Pacini F. Clinical features and therapeutic implication of papillary thyroid microcarcinoma. *Thyroid: Official journal of the American Thyroid Association* 2007; 17(11): 1085-92.
- [10] Sugitani I, Toda K, Yamada K, Yamamoto N, Ikenaga M, Fujimoto Y. Three distinctly different kinds of papillary thyroid microcarcinoma should be recognized: Our treatment strategies and outcomes. *World J Surg* 2010; 34(6): 1222-31. [http://dx.doi.org/10.1007/s00268-009-0359-x] [PMID: 20066418]
- [11] Gharib H, Papini E, Garber JR, *et al.* American association of clinical endocrinologists, association medici endocrinology and european thyroid association medical guidelines for clinical practice for the diagnosis and management of thyroid nodules. *Endocr Pract* 2016; 22(5): 622-39. [PMID: 27167915]
- [12] Tessler FN, Middleton WD, Grant EG, *et al.* ACR Thyroid Imaging, Reporting and Data System (TI-RADS): White Paper of the ACR TI-RADS Committee. *J Am Coll Radiol* 2017; 14(5): 587-95. [http://dx.doi.org/10.1016/j.jacr.2017.01.046] [PMID: 28372962]
- [13] Cibas ES, Ali SZ. The 2017 Bethesda system for reporting thyroid cytopathology. *Thyroid* 2017; 27(11): 1341-6. [http://dx.doi.org/10.1089/thy.2017.0500] [PMID: 29091573]
- [14] Hong YJ, Son EJ, Kim EK, Kwak JY, Hong SW, Chang HS. Positive predictive values of sonographic features of solid thyroid nodule. *Clin Imaging* 2010; 34(2): 127-33. [http://dx.doi.org/10.1016/j.clinimag.2008.10.034] [PMID: 20189077]
- [15] Kim DW, Lee EJ, Jung SJ, Ryu JH, Kim YM. Role of sonographic diagnosis in managing Bethesda class III nodules. *AJNR Am J Neuroradiol* 2011; 32(11): 2136-41. [http://dx.doi.org/10.3174/ajnr.A2686] [PMID: 21920860]
- [16] Kim DW, Lee YJ, Eom JW, Jung SJ, Ha TK, Kang T. Ultrasound-based diagnosis for solid thyroid nodules with the largest diameter <5 mm. *Ultrasound Med Biol* 2013; 39(7): 1190-6. [http://dx.doi.org/10.1016/j.ultrasmedbio.2013.01.016] [PMID: 23562021]
- [17] Kim DW, Park JS, In HS, Choo HJ, Ryu JH, Jung SJ. Ultrasound-based diagnostic classification for solid and partially cystic thyroid nodules. *AJNR Am J Neuroradiol* 2012; 33(6): 1144-9. [http://dx.doi.org/10.3174/ajnr.A2923] [PMID: 22300928]
- [18] Kim EK, Park CS, Chung WY, *et al.* New sonographic criteria for recommending fine-needle aspiration biopsy of nonpalpable solid nodules of the thyroid. *AJR Am J Roentgenol* 2002; 178(3): 687-91. [http://dx.doi.org/10.2214/ajr.178.3.1780687] [PMID: 11856699]
- [19] Moon WJ, Jung SL, Lee JH, *et al.* Benign and malignant thyroid nodules: US differentiation-multicenter retrospective study. *Radiology* 2008; 247(3): 762-70. [http://dx.doi.org/10.1148/radiol.2473070944] [PMID: 18403624]
- [20] Lee MJ, Kim EK, Kwak JY, Kim MJ. Partially cystic thyroid nodules on ultrasound: probability of malignancy and sonographic differentiation. *Thyroid* 2009; 19(4): 341-6. [http://dx.doi.org/10.1089/thy.2008.0250] [PMID: 19355824]
- [21] Park JY, Lee HJ, Jang HW, *et al.* A proposal for a thyroid imaging reporting and data system for ultrasound features of thyroid carcinoma. *Acta Med Indones* 2016; 48(3): 247-57. [PMID: 27840362]

- Thyroid 2009; 19(11): 1257-64.
[<http://dx.doi.org/10.1089/thy.2008.0021>] [PMID: 19754280]
- [22] Horvath E, Majlis S, Rossi R, *et al.* An ultrasonogram reporting system for thyroid nodules stratifying cancer risk for clinical management. *J Clin Endocrinol Metab* 2009; 94(5): 1748-51.
[<http://dx.doi.org/10.1210/jc.2008-1724>] [PMID: 19276237]
- [23] Kwak JY, Han KH, Yoon JH, *et al.* Thyroid imaging reporting and data system for US features of nodules: A step in establishing better stratification of cancer risk. *Radiology* 2011; 260(3): 892-9.
[<http://dx.doi.org/10.1148/radiol.11110206>] [PMID: 21771959]
- [24] Kwak JY, Jung I, Baek JH, *et al.* Image reporting and characterization system for ultrasound features of thyroid nodules: Multicentric Korean retrospective study. *Korean J Radiol* 2013; 14(1): 110-7.
[<http://dx.doi.org/10.3348/kjr.2013.14.1.110>] [PMID: 23323040]
- [25] Moifo B, Takoeta EO, Tambe J, Blanc F, Fotsin JG. Reliability of thyroid imaging reporting and data system (TIRADS) classification in differentiating benign from malignant thyroid nodules. *Open J Radiol* 2013; 3(3): 103-7.
[<http://dx.doi.org/10.4236/ojrad.2013.33016>]
- [26] Russ G. Thyroid imaging and reporting database system 2013. Available from: www.tirads.com
- [27] Russ G, Bigorgne C, Royer B, Rouxel A, Bienvenu-Perrard M. [The Thyroid Imaging Reporting and Data System (TIRADS) for ultrasound of the thyroid]. *J Radiol* 2011; 92(7-8): 701-13.
[<http://dx.doi.org/10.1016/j.jradio.2011.03.022>] [PMID: 21819912]
- [28] Russ G, Royer B, Bigorgne C, Rouxel A, Bienvenu-Perrard M, Leenhardt L. Prospective evaluation of thyroid imaging reporting and data system on 4550 nodules with and without elastography. *Eur J Endocrinol* 2013; 168(5): 649-55.
[<http://dx.doi.org/10.1530/EJE-12-0936>] [PMID: 23416955]
- [29] Middleton WD, Teefey SA, Reading CC, *et al.* Multiinstitutional analysis of thyroid nodule risk stratification using the American College of Radiology Thyroid Imaging Reporting and Data System. *AJR Am J Roentgenol* 2017; 208(6): 1331-41.
[<http://dx.doi.org/10.2214/AJR.16.17613>] [PMID: 28402167]
- [30] Middleton WD, Teefey SA, Reading CC, *et al.* Comparison of Performance Characteristics of American College of Radiology TI-RADS, Korean Society of Thyroid Radiology TIRADS, and American Thyroid Association Guidelines. *AJR Am J Roentgenol* 2018; 210(5): 1148-54.
[<http://dx.doi.org/10.2214/AJR.17.18822>] [PMID: 29629797]
- [31] Periakaruppan G, Seshadri KG, Vignesh Krishna GM, Mandava R, Sai VPM, Rajendiran S. Correlation between ultrasound-based TIRADS and Bethesda system for reporting thyroid-cytopathology: 2-year experience at a tertiary care center in India. *Indian J Endocrinol Metab* 2018; 22(5): 651-5.
[http://dx.doi.org/10.4103/ijem.IJEM_27_18] [PMID: 30294576]
- [32] Modi L, Sun W, Shafizadeh N, *et al.* Does a higher American College of Radiology Thyroid Imaging Reporting and Data System (ACR TI-RADS) score forecast an increased risk of malignancy? A correlation study of ACR TI-RADS with FNA cytology in the evaluation of thyroid nodules. *Cancer Cytopathol* 2020; 128(7): 470-81.
[<http://dx.doi.org/10.1002/cncy.22254>] [PMID: 32078249]