Original Article

Prospective Validation of Accuracy of American College of Radiologists- Thyroid Imaging Reporting and Data System (ACR-TIRADS) in Diagnosing Malignancy in Thyroid Nodule and a Prediction Score (TiPS) for Thyroid Malignancy

Soumya Sarayu, Abilash Nair, Jabbar P. Khader, Sree P. P. Rema[1], Sulfekar Meerasainaba[2], Sarath Kumar[3], Ramesh Gomez, Jayakumari Chellamma

Departments of Endocrinology and Metabolism, [1]Radiodiagnosis and [3]Pathology, Government Medical College, Thiruvananthapuram, [2]Department of General Surgery, Government Medical College, Kollam, Kerala, India

Abstract

Introduction: Studies on diagnostic accuracy of revised ACR-TIRADS have been mostly retrospective and includes selection bias for surgery. **Methods:** Consecutive subjects >12 years of age, with palpable or ultrasound-revealed thyroid nodule, were included in the study. Nodules of size >1 cm or TIRADS score 4 or 5 >5 mm underwent ultrasound-guided FNAC. All Bethesda 4, 5 and 6 nodules underwent thyroidectomy. Patients with Bethesda 3 nodules were given options of close follow up or surgery. **Results:** There were 253 benign (Bethesda 2), 23 malignant (Bethesda 6) and 41 indeterminate (Bethesda 3,4,5) nodules. Among 41 indeterminate nodules, 19 underwent surgery of which 14 were malignant. 295 nodules had a definitive outcome (defined as final outcome variable); which could be a benign cytology report or a histopathology report. Proportion of thyroid cancer was 12.5%. ACR-TIRADS had a sensitivity of 100% and specificity of 60.5%, considering final outcome variable as gold standard and ACR-TIRADS 1-3 as test negative and score 4-5 positive. Lower age and higher serum TSH level were associated with malignancy ($P < 0.05$). Predictive scoring system was formulated with age, TSH, ACR-TIRADS and Bethesda. Cumulative score of 6 (IQR 4.5- 6.5) or above had a sensitivity and specificity of 96.2%, and 97.5% respectively and negative predictive value of 99.5%. **Conclusion:** Owing to high sensitivity, ACR-TIRADS can be considered as a good tool to rule-out malignancy, but not to predict the same due to lower specificity. Cumulative scoring system had high diagnostic accuracy for prediction of malignancy risk and can be a useful tool for selecting nodules for surgery.

Keywords: ACR TIRADS, Bethesda cytology thyroid, fine needle aspiration cytology, follicular carcinoma thyroid, papillary carcinoma thyroid, thyroid nodule

Introduction

The average prevalence of malignancy rates across the world in thyroid nodules from different studies selecting high risk nodules for further evaluation, as evaluated by invasive procedures ranges from 5 to15%.[1,2] In India, incidence of differentiated thyroid cancer (DTC) has increased over a decade by 62% and 48% in women and men respectively.[3]

To stratify the risk for malignancy and for selection of thyroid nodules for fine-needle aspiration cytology (FNAC), ultrasound-based (US) risk-stratification systems have been developed by many national and international thyroid societies and by the American College of Radiologists (ACR).[4] The

Supplementary material available online: https://journals.lww.com/indjem/

Access this article online

Quick Response Code:

Website: https://journals.lww.com/indjem/

DOI: 10.4103/ijem.ijem_324_23

Address for correspondence: Dr. Soumya Sarayu, Department of Endocrinology and Metabolism, Government Medical College, Thiruvananthapuram, Kerala, India.
E-mail: soumya.kurup88@gmail.com

Submitted: 28-Jul-2023 **Revised:** 25-Nov-2023
Accepted: 06-Feb-2024 **Published:** 28-Feb-2025

How to cite this article: Sarayu S, Nair A, Khader JP, Rema SP, Meerasainaba S, Kumar S, *et al.* Prospective validation of accuracy of American college of radiologists- thyroid imaging reporting and data system (ACR-TIRADS) in diagnosing malignancy in thyroid nodule and a prediction score (TiPS) for thyroid malignancy. Indian J Endocr Metab 2025;29:101-7.

various ultrasound stratification systems also recommend size cut off criteria above which biopsy is indicated. Among various US risk stratification systems, the revised ACR TIRADS published in 2017 is considered to be more objective with lesser interobserver variability.[5]

Most studies on diagnostic accuracy of 2017 ACR TIRADS were retrospective where histopathological reports were correlated with ultrasound report derived TIRADS score. Hence it includes selection bias for surgery. Molecular diagnostic study for indeterminate nodules are not accessible to most parts of the population. Hence clinician has to rely upon clinical, ultrasound and cytological characteristics to take a decision for surgery in indeterminate nodules. Diagnosing thyroid malignancy while keeping oneself within the narrow balance between overdiagnosis and underdiagnosis is a relevant clinical concern. We aim to study the diagnostic accuracy of revised ACR TIRADS prospectively and formulate a cumulative prediction scoring system for malignancy in thyroid nodule.

Materials and Methods

All patients, 12 years of age or above, with thyroid nodule on palpation or by ultrasonography, attending the Endocrinology Outpatient department, during the study period were consecutively included in the study after getting written informed consent. Those patients who already have a diagnosis of thyroid cancer by FNAC from elsewhere, or lobectomy with histopathology report of thyroid cancer and nodules in the residual thyroid were not included. Hormonal parameters evaluated include serum total thyroxine (T4), Thyroid stimulating hormone (TSH) and Anti TPO antibody levels. The hormonal evaluation was done by electrochemiluminescence method (ECLIA) using Cobas e 411 analysers with commercially available Elecsys kits (Roche, Germany).

All consecutive patients who did not meet exclusion criteria; (pregnancy, thyrotoxic state) were selected for the study. All those patients underwent ultrasonography by a single qualified radiologist experienced in reporting TIRADS. The ultrasound machine used was Philips IU22 machine equipped with L17-5 transducer (high frequency broadband linear array transducer). Inclusion criteria was then applied. Nodules were taken up for further evaluation by FNAC if they met the following criteria; a) All nodules more than or equal to 1cm in maximum diameter b) All nodules more than 5 mm if TIRADS score was 4 or 5. Maximum of three nodules were selected for FNAC from one patient. In those patients with more than three nodules, three nodules with highest TIRADS score were taken for FNAC. In case of same TIRADS score, the next criteria for selection was maximum diameter of the nodule. Ultrasound guided FNAC was done from all nodules by the principal investigator. For hyperthyroid patients, euthyroidism was achieved before performing FNAC.

Subjects with Bethesda category 4, 5 and 6 nodules underwent total thyroidectomy. Those nodules with cytology report of Bethesda 1 underwent repeat FNAC after 1 month of the initial FNAC. Those nodules with a report of Bethesda 3 were given options of close follow up or surgery. Bethesda 3 nodules were given the treatment options of active follow up versus upfront surgery; patients preferring surgery were facilitated for the same. Large nodules causing pressure symptoms were advised surgery irrespective of Bethesda or TIRADS score.

Ethical aspects

The study was approved by the Institutional research committee and the Human ethics committee, Government Medical College, Thiruvananthapuram vide letter number HEC.No.06/04/2019/MCT dated 10.05.2019, for a period of one and half years from the date of ethics committee approval. Written informed consent was obtained for participation in the study and use of the patient data for research and educational purposes. All the procedures followed the guidelines laid down in Declaration of Helsinki 1964 and as revised later.

Results

Three hundred and forty six nodules were detected in 246 patients and 2017 ACR TIRADS score were noted for each of them. Inclusion criteria was applied. Twenty five nodules from 22 patients did not satisfy inclusion criteria. Three hundred and twenty one nodules from 224 patients satisfied inclusion criteria and were selected for FNAC. They underwent ultrasound guided FNAC by single investigator. Four nodules had FNAC report of Bethesda 1 or non diagnostic category on repeated FNAC and were excluded from analysis. Thus, 317 nodules from 220 patients were included for analysis [Figure 1]. Baseline characteristics of study population are given in Table 1. There were 253 (Bethesda 2), 31 (Bethesda 3), 5 (Bethesda 4), 5 (Bethesda 5) and 23 (Bethesda 6) nodules. The distribution of ACR TIRADS scores within different Bethesda Category

Table 1: Baseline characteristics of the study population

Parameter (n=220 patients)	Mean±SD/Median (IQR)/ Frequency (Percentage)
Mean age (years)	43.0±13.69
Males	25 (11.4%)
Females	195 (88.6%)
Body Mass Index (kg/m^2)	24.75±3.12
Euthyroid	154 (70%)
Hypothyroid	50 (22.7%)
Hyperthyroid	16 (7.27%)
Goitre	
0	15 (6.25%)
1	41 (17.08%)
2	164 (74.5%)
Mean TSH of euthyroid group (mIU/L)	1.74±1.15
Anti Thyroid peroxidase antibody levels	
Positive	96 (43.63%)
Negative	124 (56.36%)
Nodules	
Solitary	42 (19.09%)
Multiple	178 (80.9%)
Mean Size (mm)	21.03±7.09

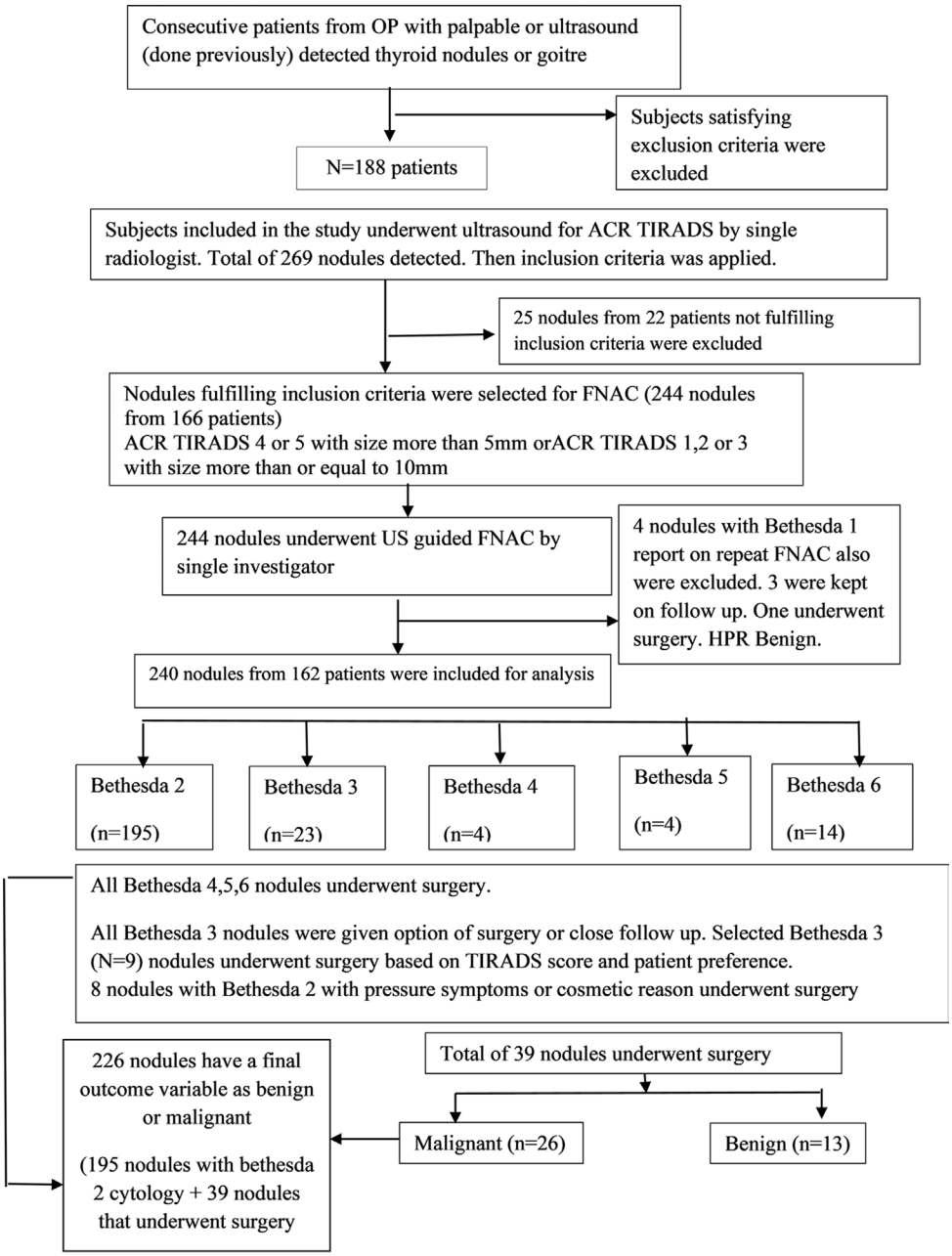

Figure 1: Flow of patients in the study

results of the nodules are given in Table 2. All Bethesda 4, 5, 6 nodules, 9 Bethesda 3 nodules and 8 nodules with Bethesda 2 with pressure symptoms underwent surgery. Total of 50 nodules hence underwent surgery. The rate of malignancy on histopathology (HPR) were 100% for Bethesda 6, 100% for Bethesda 5, 60% for Bethesda 4, 66% for Bethesda 3.

Final outcome variable was defined as FNAC report of Bethesda 2 or all other nodules which had undergone surgery and HPR is available. Excluding the 22 Bethesda 3 nodules (from 20 patients) who did not undergo surgery, for which a definitive answer whether benign or malignant is not available, a total of 295 nodules (from 200 patients) had a definitive outcome at the end of the study; which could be a benign cytology report on FNAC or a histopathology report after surgery. Out of the 295 nodules with final outcome variable, 258 nodules were benign and 37 nodules malignant. Out of the 37 nodules with malignant histopathological reports, 33 were papillary carcinoma; 3 follicular carcinoma; 1 Hurthle cell carcinoma.

Considering final outcome variable as gold standard and ACR TIRADS score 1,2 or 3 as test negative and score 4 or 5 as test positive, the diagnostic performance of ACR TIRADS were: sensitivity 100%, specificity 60.5%, positive predictive value 26.6%, negative predictive value 100%.

Performance of individual ultrasound features in predicting malignancy were assessed. The sensitivity and specificity

of each were: solid nodule (87.5%, 52.1%), hypoechoic and very hypoechoic (62.5%, 68.8%), taller than wide (12.5%, 98.38%), margin: lobulated/irregular and extra thyroidal extension (50%, 89.24%), punctate echogenic foci (93.75%, 94.62%), presence of lymph nodes with suspicious features (38.46%, 98.5%).

The baseline characteristics between benign and malignant nodules were compared [Table 3]. Patients having multiple nodules with atleast one malignant nodule were grouped under malignant. Out of the 37 malignant nodules, 4 patients had multinodularity with a benign nodule also. These 4 benign nodules were excluded from the benign group. So the baseline characteristics of 37 malignant nodules from 37 patients and 254 nodules from 163 patients were compared. Age and serum TSH level (compared only for euthyroid patients) were found to be significantly different between the groups. Younger age and a higher serum TSH level was found to be significantly associated with malignancy.

A prediction score (named as Trivandrum prediction score (TiPS)) was formulated with four variables namely age, TSH, 2017 ACR TIRADS score and Bethesda score, for predicting risk of malignancy in thyroid nodule. The AUC values of the components are as follows: Age 0.405 (SE 0.062), TSH 0.589 (SE 0.062), ACR TIRADS 0.874 (SE 0.029), Bethesda 0.999 (SE 0.001). Each of the four variables were stratified and weightage points assigned and individual scores added [Table 4]. ROC curve was analysed for cut off value of total prediction score which can predict risk for malignancy with final outcome variable as the gold standard [Figure 2]. Youden index was maximum (0.937) for a total predictive score value between 5 and 6 (5.5). Total score of 6 or more had a sensitivity of 96.2% and specificity of 97.5% in predicting malignancy. Positive predictive value was 83.3%, and negative predictive value 99.5%.

Discussion

The advantage and clinical utility of objective point based ultrasound classification system over pattern based systems for stratification of malignancy risk in thyroid nodules have been subject of interest lately. Yoon *et al.*[6] have demonstrated that the ATA guidelines were unable to classify 3.4% of 1,293 nodules, of which 18.2% were malignant. Other comparative studies have demonstrated a sensitivity of ACR TIRADS 2017 ranging from 75-97% and specificity ranging 53-67%,[7] which is the highest sensitivity and lowest specificity amongst compared systems [Supplementary Table 1].[5,7-10]

Overall, from various studies ACR TIRADS system had better test performance characteristics predicting malignancy and avoiding unnecessary biopsies. The present study is also in agreement with it. The main reason for the better performance of ACR TIRADS considered could be the objectivity of the assessment based on points. More combinations of ultrasound characteristics could be classified.

In the present study, punctate echogenic foci, solid composition and hypoechogenicity were the ultrasound characteristics of nodule that better predicted malignancy with a sensitivity of 93.755, 87.5% and 62.5% respectively. Taller than wide shape had a specificity of 98.38% but sensitivity of 12.5% only. It may be due to the decreased specificity in reporting this feature in smaller nodules or lack of a pathological basis for such a

Table 2: ACR TIRADS score and Bethesda category distribution of the study population

	Bethesda 2	Bethesda 3	Bethesda 4	Bethesda 5	Bethesda 6	Row total
TIRADS 1	2	0	0	0	0	2
TIRADS 2	59	1	0	0	0	60
TIRADS 3	93	6	1	0	0	100
TIRADS 4	79	16	2	3	5	105
TIRADS 5	20	8	2	2	18	50
Column total	253	31	5	5	23	317

Table 3: Comparison of baseline characteristics between benign and malignant nodules

	Malignant ($n=37$ patients)	Benign ($n=163$ patients)	*P*
Age	35.08±13.78	43.69±13.07	0.002
Gender			0.41
Males: Females	1:25	1:7	
SIZE (mm)	21.97±11.39	22.68±12.15	0.78
BMI (kg/m^2)	23.71±3.38	24.98±3.05	0.051
TSH	2.48+1.49	1.62+1.03	0.002
Thyroid status			0.52
Euthyroid	25 (67.5%)	98 (60.1%)	
Hypothyroid	9 (24.3%)	42 (25.8%)	
Hyperthyroid	3 (8.1%)	23 (14.1%)	
Anti TPO antibody status (positive)	15 (40.5%)	73 (44.8%)	0.64

Table 4: Prediction score for malignancy in thyroid nodule

Variable	Categories	Points assigned
Age (in years)	>40	0
	<40	1
TSH (mIU/L)	<2	0
	>2 or on treatment for hypothyroidism	1
2017 ACR TIRADS score [ACR TIRADS score -1]	1	0
	2	1
	3	2
	4	3
	5	4
Bethesda category [Bethesda category – 2]×2	2	0
	3	2
	4	4
	5	6
	6	8

TiPS=age score + TSH score + [TIRADS-1] + [Bethesda -2]×2

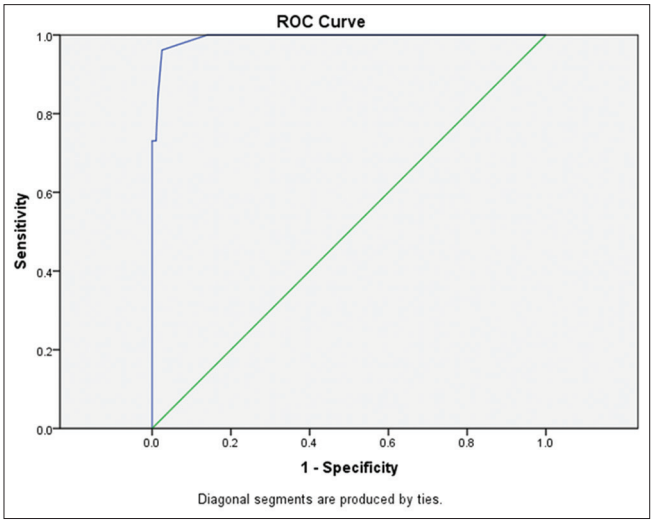

Figure 2: ROC curve for cut off value of total Trivandrum prediction score (TiPS) which can predict risk for malignancy with final outcome variable as the gold standard

shape in malignancy. In the present study, presence of cervical lymph node with features suspicious of malignancy such as loss of fatty hilum had a sensitivity of 38.46% and specificity of 98.5% in predicting malignancy. In a study by Liu *et al.*,[11] loss of echogenic fatty hilum in cervical lymph node had a sensitivity of 29.7% and specificity of 98.7% in predicting malignancy. Henrichsen *et al.*[12] showed that out of 360 malignant nodules 88% were either entirely solid or less than 5% cystic. Hypoechogenicity and markedly hypoechoic, are associated with an increased risk for malignancy according to Moon *et al.*[13] Punctate echogenic foci that lack the comet-tail sign, are more likely to represent microcalcifications, and are typically associated with papillary thyroid cancer in several studies.[14] The presence of punctate echogenic foci on sonography was 74% sensitive, was 46% to 53% specific in studies.[15]

Among the baseline characteristics of the study population, younger age and higher serum TSH level were significantly associated with malignancy. In a study by Kwong *et al.*,[16] between the ages of 20 and 60 years, each advancing year in age was associated with a 2.2% reduction in the relative risk that any newly evaluated thyroid nodule was malignant in a patient and the risk of malignancy stabilized after age 60 years. Kwong *et al.*[16] demonstrated a linear increase in the number of thyroid nodules per patient with age, a 1.6% annual increased risk for multinodularity. In the study population, as the patients age increased from 20 years to more than 70 years, the cancer risk decreased by every decade from 22.9% to 12.6% ($P < 0.001$).[17]

Haymart *et al.*[18] demonstrated that, higher serum TSH concentrations, even within the normal reference range, is an independent risk factor that a thyroid nodule is cancerous. Serum TSH level of ≥2.7 mIU/L predicted thyroid malignancy with a sensitivity of 61% and a specificity of 65% in euthyroid patients affected by thyroid nodules with indeterminate cytology.[19]

Indeterminate nodules and nodules with high TIRADS score but Bethesda 2 cytology usually pose a dilemma for the treating clinician to take a decision for surgery or follow up. Non availability and affordability of molecular studies are another limitation. Hence scoring systems which takes into consideration multiple risk factors for malignancy could aid management of thyroid nodules without overtreating them. Kannan and Mehta[20] has proposed a scoring system considering summated score of 2017 ACR TIRADS and Bethesda score. A BETHTR score ≥7 gave a sensitivity of 92% specificity of 74% and correctly identified malignant nodules in 86% of cases. Another predictive model was proposed with the following parameters: TSH >2.5 = 1, Age-group <30 or >60 = 1, presence of microcalcification = 2, male gender = 2, irregular nodule margins = 2, mixed echogenicity = 1, and hypoechogenicity = 2. Overall, scores >4 were highly sensitive (86.9%), whereas >7 were highly specific (94.87%) for malignancy; and in patients with indeterminate cytology, the negative predictive value of a score of 2 or less was 95–100%.[21] A Predictive Model for Selecting Malignant Thyroid Nodules in Patients With Nondiagnostic or Indeterminate Fine-Needle Aspiration Cytologic Findings integrating TI-RADS category, elastographic score and cytologic finding was published by Lin *et al.*[22] Sensitivity and specificity for a score higher than 3 reached 79.37% and 85.85%, respectively, and the positive and negative predictive values were 76.9% and 87.3%. Prediction score (TiPS) formulated from present study had higher specificity of 97.5% when compared to ACR TIRADS alone, while retaining a high sensitivity and negative predictive value.

The strengths of the study are that, the study had prospectively validated the diagnostic accuracy of 2017 revised ACR TIRADS, thus avoiding the selection bias seen in retrospective studies on validation of ultrasound risk stratification systems with histopathology reports. Hence, the study represents the malignancy risk in a thyroid nodule before surgery itself and

also helps in selecting nodules that need to undergo further evaluation and surgery.

The limitations of the study are that, in the present study patients with Bethesda 2 report on FNAC were considered as benign for analysis of predictive accuracy of 2017 ACR TIRADS. Gold standard for analysis of malignancy in thyroid nodule is considered to be surgery and histopathological report; but the same may not be ethical to be done in all Bethesda 2 nodules. The number of indeterminate nodules in this study are less for separate analysis.

Conclusion

ACR-TIRADS is a sensitive tool in selecting nodules for malignancy evaluation agreeing with the previous studies. Owing to its high sensitivity and lower specificity, it should be considered as a valid tool to rule out malignancy but not to predict the same. Hence tests with higher specificity like Bethesda system on FNAC continues to hold a significant position as an additional investigation to Ultrasonography, in the evaluation of thyroid nodule for diagnosing malignancy.

Predictive score (TiPS) combining multiple risk variables such as age, TSH level, 2017 ACR TIRADS and Bethesda could predict malignancy with better specificity and sensitivity than either ACR TIRADS or Bethesda alone and can help clinician to plan further management of thyroid nodule without overtreating them.

Acknowledgement

I thank my patients who have participated in the study. I extend my sincere thanks to Dr. Ramesh Gomez, Dr. C. Jayakumari for their valuable comments in editing the manuscript. I extend my appreciation and thanks to Dr. Anish T, for the valuable guidance in statistical analysis of the work. I extend my sincere thanks to my colleagues, Dr. Geena, Dr. Nandini, Dr. Ajeesh, Dr. Karthik, Dr. Shameer, Dr Sandra and Dr Rameez for their help. I thank Dr Arun Kumar A for his valuable comments and advice.

Author contribution

Author 1: did conception of the research idea, designed the work, did Ultrasound guided FNAC on all the study subjects, collected data and did analysis and interpretation (ICMJE Criteria 1). Author 2: did critical revision for important intellectual content (ICMJE Criteria 2). Author 3: did critical revision and final approval of the version to be published (ICMJE Criteria 3). Author 4: acquisition of data for the study by doing ultrasound thyroid for all study subjects and ACR TIRADS scoring(ICMJE Criteria 1). Author 5: acquisition of data for the study by doing thyroidectomy for indicated study subjects(ICMJE Criteria 1). Author 6: acquisition of data for the study by doing cytological analysis on FNAC and reviewed histopathological reports (ICMJE Criteria 1).

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Data availability

Authors declare that the data related to the study will be made available upon request.

References

1. Brito JP, Yarur AJ, Prokop LJ, McIver B, Murad MH, Montori VM. Prevalence of thyroid cancer in multinodular goiter versus single nodule: A systematic review and meta-analysis. Thyroid 2013;23:449–55.
2. Frates MC, Benson CB, Doubilet PM, Kunreuther E, Contreras M, Cibas ES, *et al.* Prevalence and distribution of carcinoma in patients with solitary and multiple thyroid nodules on sonography. J Clin Endocrinol Metab 2006;91:3411–7.
3. Sekkath Veedu J, Wang K, Lei F, Chen Q, Huang B, Mathew A. Trends in thyroid cancer incidence in India. J Clin Oncol 2018;36:e18095–5.
4. Tessler FN, Middleton WD, Grant EG, Hoang JK, Berland LL, Teefey SA, *et al.* ACR thyroid imaging, reporting and data system (TI-RADS): White paper of the ACR TI-RADS committee. J Am Coll Radiol 2017;14:587–95.
5. Xu T, Wu Y, Wu RX, Zhang YZ, Gu JY, Ye XH, *et al.* Validation and comparison of three newly-released thyroid imaging reporting and data systems for cancer risk determination. Endocrine 2018;64:299–307.
6. Yoon JH, Lee HS, Kim EK, Moon HJ, Kwak JY. Malignancy risk stratification of thyroid nodules: Comparison between the thyroid imaging reporting and data system and the 2014 American thyroid association management guidelines. Radiology 2016;278:917–24.
7. Ha EJ, Na DG, Baek JH, Sung JY, Kim J, Kang SY. US fine-needle aspiration biopsy for thyroid malignancy: Diagnostic performance of seven society guidelines applied to 2000 thyroid nodules. Radiology 2018;287:893–900.
8. Ha EJ, Na DG, Moon WJ, Lee YH, Choi N. Diagnostic performance of ultrasound-based risk-stratification systems for thyroid nodules: Comparison of the 2015 American thyroid association guidelines with the 2016 Korean thyroid association/Korean society of thyroid radiology and 2017 American college of radiology guidelines. Thyroid 2018;28:1532–7.
9. Grani G, Lamartina L, Ascoli V, Bosco D, Biffoni M, Giacomelli L, *et al.* Reducing the number of unnecessary thyroid biopsies while improving diagnostic accuracy: Toward the "Right" TIRADS. J Clin Endocrinol Metab 2018;104:95–102.
10. Zheng Y, Xu S, Kang H, Zhan W. A single-center retrospective validation study of the American college of radiology thyroid imaging reporting and data system. Ultrasound Q 2018;34:77–83.
11. Liu Z, Zeng W, Liu C, Wang S, Xiong Y, Guo Y, *et al.* Diagnostic accuracy of ultrasonographic features for lymph node metastasis in papillary thyroid microcarcinoma: A single-center retrospective study. World J Surg Oncol 2017;15:32.
12. Henrichsen TL, Reading CC, Charboneau JW, Donovan DJ, Sebo TJ, Hay ID. Cystic change in thyroid carcinoma: Prevalence and estimated volume in 360 carcinomas. J Clin Ultrasound 2010;38:361–6.
13. Moon WJ, Jung SL, Lee JH, Na DG, Baek JH, Lee YH, *et al.* Benign and malignant thyroid nodules: US differentiation—multicenter retrospective study. Radiology 2008;247:762–70.
14. Kwak JY, Han KH, Yoon JH, Moon HJ, Son EJ, Park SH, *et al.* Thyroid imaging reporting and data system for US features of nodules: A step in establishing better stratification of cancer risk. Radiology 2011;260:892–9.
15. Tahvildari AM, Pan L, Kong CS, Desser T. Sonographic-pathologic correlation for punctate echogenic reflectors in papillary thyroid carcinoma. J Ultrasound Med 2016;35:1645–52.
16. Kwong N, Medici M, Angell TE, Liu X, Marqusee E, Cibas ES, *et al.* The influence of patient age on thyroid nodule formation, multinodularity, and thyroid cancer risk. J Clin Endocrinol Metab 2015;100:4434–40.

17. Lima PCM, Moura Neto A, Tambascia MA, Zantut Wittmann DE. Risk factors associated with benign and malignant thyroid nodules in autoimmune thyroid diseases. ISRN Endocrinol 2013;2013:673146.
18. Haymart MR, Repplinger DJ, Leverson GE, Elson DF, Sippel RS, Jaume JC, *et al.* Higher serum thyroid stimulating hormone level in thyroid nodule patients is associated with greater risks of differentiated thyroid cancer and advanced tumor stage. J Clin Endocrinol Metab 2008;93:809–14.
19. Cappelli C, Pirola I, Gandossi E, Rotondi M, Lombardi D, Casella C, *et al.* Could serum TSH levels predict malignancy in euthyroid patients affected by thyroid nodules with indeterminate cytology? Int J Endocrinol 2020;2020:7543930.
20. Kannan S, Mehta S. Approaching indeterminate thyroid nodules in the absence of molecular markers: "The BETH-TR score." Indian J Endocrinol Metab 2020;24:170-5.
21. Witczak J, Taylor P, Chai J, Amphlett B, Soukias JM, Das G, *et al.* Predicting malignancy in thyroid nodules: Feasibility of a predictive model integrating clinical, biochemical, and ultrasound characteristics. Thyroid Res 2016;9:4.
22. Lin K, Xiang Y, Qiao L, Liu R, Dong S, Zhang X. A predictive model for selecting malignant thyroid nodules in patients with nondiagnostic or indeterminate fine-needle aspiration cytologic findings. J Ultrasound Med 2015;34:1245–51.

Supplementary Table 1: Comparison of predictive accuracy of 2017 ACR TIRADS in various studies

Study	Number of nodules	Sensitivity	Specificity
Ha *et al*., 2018[7]	2000	74.7%	67.3%
Ting Xu *et al*., 2019[5]	2465	96.6%	52.9%
Ha EJ *et al*., 2018[8]	902	80.2%	68.9%
Grani *et al*., 2018[9]	477	83.3%	56.2%
Zheng *et al*., 2018[10]	1033	99%	43.4%
Present study	317	100%	61.53%