Updated ACR Thyroid Imaging Reporting and Data Systems in risk stratification of thyroid nodules: 1-year experience at a Tertiary Care Hospital in Al-Qassim

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Background
Thyroid imaging reporting and data system (TI-RADS) is assessment of risk stratification of thyroid nodules, using a score. A novel ACR (American College of Radiology) TI-RADS has been recently suggested by American College of Radiology. But, the utility of ACR TI-RADS in risk stratification for thyroid lesion needs further evaluation.
Aim
Of this study was to evaluate ACR TI-RADS classification in discriminating benign and from other thyroid lesions as detected by fine needle aspiration cytology (FNAC).
Methods
This retrospective study included all patients referred to our institute for FNAC of a thyroid nodule over 1 year. Thyroid nodules were categorized according to the 2017 ACR TI-RADS. Ultimately, efficacy of ACR TI-RADS in differentiating benign from non-benign nodules was assessed using ROC curve, cross-tabulation, and Chisquare tests. According to the results of FNAC, nodules were classified into 2 groups; benign lesions (Bethesda II) and malignant lesions (Bethesda IV, V).
Results
The percentages of Bethesda IV and V lesions defined in our ACR-TIRADS were as follows: ACR TI-RADS 1, 2 (0%), ACR TI-RADS 3 (4%), ACR TI-RADS 4 (6.6%), and ACR TI-RADS 5 (22.6%). ROC curve analysis for ACR TI-RADS to differentiate benign from non-benign pathology showed (AUC 0.60, 95% CI: 0.505–0.713). ACR TI-RADS had sensitivity, specificity, positive predictive value and negative predictive value 75%, 62.35 %, 15.7%, 96.3% respectively.
Conclusion
Differentiation between benign and malignant thyroid lesion can be suggested from the ultrasound based ACR TI-RADS system. FNAC might be deferred in patients having ACR TI-RADS 1 and 2.

Keywords:
ACR Thyroid Imaging Reporting and Data Systems ultrasound, cytology, thyroid nodules

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Introduction

The prevalence of thyroid nodules in population is increasing all over the world. The estimated incidence of thyroid nodules is ~19–67%; nearly 5–15% of these nodules are malignant [1]. Although fine-needle aspiration cytology (FNAC) is the standard method for evaluation of thyroid nodules, it is painful, relatively costly, and sometimes leads to infection or bleeding [2]. Approximately 10–20% of fine-needle aspiration biopsies are not conclusive, and aspiration needs to be repeated [3]. Furthermore, approximately only 3–7% of thyroid FNACs have conclusive features of malignancy [4]. Therefore, there is a growing urgent need to have a reliable ultrasound noninvasive classification for the assessment of the thyroid lesions and to differentiate between a benign and other lesions with a good level of conviction, thereby reducing the number of unnecessary invasive biopsies.

High-resolution US is a simple, safe, cost-effective, widely available, and easily reproducible method for diagnosis of thyroid nodules [5]. Radiologic features related to increased possibility of malignancy of a thyroid nodule include hypoechogenicity, margin irregularity, microcalcifications, increased vascularity inside the nodule, incomplete halo, and a taller than-wide shape evaluated in the transverse dimension. Thus, several benign and malignant US gray-scale and Doppler

features have emerged over the past years that may be used in different ways to assign probabilities [6].

Thyroid nodules cannot be considered benign or malignant based on a single sonographic criterion. Several US Thyroid Imaging Reporting and Data Systems (TI-RADS) have been suggested for risk classification of thyroid nodules [4]. The terminology of TI-RADS was first used by Horvath *et al*. [7]. They defined 10 forms of thyroid nodules determined by US and verified the rate of malignancy based on the form. Recently, Tessler *et al*. [8] proposed American College of Radiology (ACR) TI-RADS score that refers to five risk features: microcalcification, irregular shape, taller-than-wide, solidity, and hypoechogenicity. The risk of malignancy rises with the increase in the number of suspicious US features. However, clinical use of ACR TI-RADS is still very limited, and its practical application in clinical practice needs further evaluation.

This study was done retrospectively to investigate the diagnostic value of ACR TI-RADS classification system proposed by Tessler and colleagues in differentiating between a benign and nonbenign lesions and to investigate the value for each of these US features separately aiming at reduction in the number of unnecessary biopsies.

Patients and methods

Study design

The study was a retrospective one. All patients referred to our institute for FNAC of a thyroid nodule between May 2017 and December 2017 were retrospectively included.

Patients and methods

The study included 123 patients. The data collected included age, sex, history of neck irradiation, family history of thyroid cancer, medications for thyroid disease, and thyroid-stimulating hormone level. The study protocol and procedures follow to the ethical guidelines of the 1975 Declaration of Helsinki. The study was approved by the Qassim Regional Research Ethics Committee. No consent has been obtained as the study was retrospective.

Before the biopsy, the patients were examined by one of the two US systems: GE Logiq E9 (GE Healthcare, Milwaukee, Washington, USA) and Philips iU 22 (Philips Healthcare, Bothell, Washington, USA) using a 5–12-MHz linear transducer. The original US images were retrospectively reviewed by two radiologists with more than 5 years of experience. The radiologists recorded their judgment on the US findings of the biopsied nodule using standardized rating system based on the 2017 ACR TI-RADS [8]. Judgment was made jointly to overcome interobserver variability. The nodules were evaluated on five main elements: composition, echogenicity, shape, margins, and echogenic foci. Each nodule was assigned to specific ACR TI-RADS score. The US features in the ACR TI-RADS are classified as follows: 1 as benign, 2 as not suspicious, 3 as minimally suspicious, 4 as moderately suspicious, or 5 as highly suspicious for malignancy [8].

Bethesda classification of these nodules was tabulated from the medical record. According to Bethesda classification, the risk of malignancy is 0–3% for Bethesda II (benign), 6–18% for Bethesda III (atypia of undetermined significance or follicular lesion of undetermined significance), 10–40% for Bethesda IV (follicular neoplasm), 45–60% for Bethesda V (suspicious), and 94–96% for Bethesda VI (malignant) [9]. Accordingly, the lesions were classified according to FNAC results into two groups: group 1 (benign lesions: Bethesda II) and group 2 (malignant lesions: Bethesda IV and V)

Statistical analysis

Data were analyzed through the Statistical Package of Social Science Software program, version 23 (IBM SPSS Statistics for Windows, Version 23.0.; IBM Corp., Armonk, New York, USA) to be statistically analyzed. Data were presented using range, mean, and SD for quantitative variables and frequency and percentage for qualitative ones. Comparison between groups was conducted using independent sample *t* test (if parametric data) and Mann–Whitney test (if nonparametric data) for quantitative variables, whereas comparison of qualitative variables was performed through Chi square test. Receiver operating characteristic analyses were done to determine the sensitivity of TI-RADs in identifying benign lesions. *P* values less than 0.05 were considered statistically significant.

Results

The study included 123 patients; 87% of them were females and 13% were males. Most of our patients were between 30 and 50 years. Most thyroid nodules were solitary (79.7%), and most of them were clinically palpable; the nodule size ranged between 1 and 4 cm (Table 1).

Table 1 Clinical and ultrasound data of studied population

Features	Description (*N*=123)
Age (years)	
Range	14–79
Mean±SD	41±13.3
Sex [*n* (%)]	
Male	16 (13)
Female	107 (87)
History of head and neck ionizing radiation [*n* (%)]	
Yes	2 (1.8)
No	109 (98.2)
Family history of thyroid cancer [*n* (%)]	
Yes	2 (1.8)
No	109 (98.2)
Palpable thyroid nodule [*n* (%)]	
Yes	95 (77.2)
No	28 (22.8)
Nodule size [*n* (%)]	
>1.5 cm	100 (81.3)
TSH (mU/l)	
Range	0.2–18.2
Mean±SD	2.7±2.7
Treatment with L-thyroxin [*n* (%)]	
Yes	35 (28.5)
No	88 (71.5)
Nodule laterality [*n* (%)]	
Yes	25 (20.3)
No	98 (79.7)

TSH, thyroid-stimulating hormone.

Regarding US results, 43% of thyroid nodules came under ACR TI-RADS 3, 24.4% were classified as ACR TI-RADS 4, 18% were classified as ACR TI-RADS 5, 13.8% were classified as ACR TI-RADS 2, and only one nodule had ACR TI-RADS 1. Most of the nodules (62.6%) were found to be Bethesda II (Table 2).

The nodules classified as Bethesda II were considered benign, and those nodules classified as Bethesda IV–V were considered malignant. Patients with nonbenign nodules had higher thyroid-stimulating hormone values than patients with benign nodules. Regarding US results, the significant findings associated with the malignant nodules were the presence of irregular margin and punctate foci of calcification (Table 3).

Of the 17 ACR TI-RADS 2 nodules, none were found to be in Bethesda IV or higher, which denotes none of these nodules were malignant. Among the 53 nodules categorized as ACR TI-RADS 3, 29 nodules were in Bethesda II and two nodules were in Bethesda IV. There were 30 nodules classified under ACR TI-RADS 4, and two of them were in Bethesda IV and V and 22 nodules under ACR TI-RADS 5, and five of them were in Bethesda IV and V. Thus, the risk of the nodule to be malignant as classified by ACR TI-RADS 2, ACR TI-RADS 3, ACR TI-RADS 4, and ACR TI-RADS 5 was 0.0, 3.7, 6.6, and 22.7%, respectively.

Cross-tabulation of ACR TI-RADS and Bethesda classification showed that sensitivity, specificity, negative predictive value, positive predictive value, and accuracy of ACR TI-RADS scores 4 and 5 as positive scores for malignancy were 75, 62.35, 15.7, and 96.3%, respectively. χ^2 test was used for comparing ACR TI-RADS result with Bethesda system of classification (P=0.04) (Table 4).

Receiver operating characteristic curve drawn to assess the diagnostic performance of ACR TI-RADS compared with conclusive FNAC results showed an area under the curve of 0.687 (95% confidence interval: 0.501–0.873) (Fig. 1).

Discussion

The value of US in discriminating benign from malignant thyroid nodules has been proved in many of previous studies [10–12]. Many scoring systems have been evaluated to identify the risk of malignancy in the thyroid nodules [13–15]. However, many of these systems are complex, time consuming, and are not easily applied. ACR TI-RADS score proposed recently is a simple and practical system in evaluating thyroid nodules [8]. In spite of that, ACR TI-RADS system is not applied in many areas of Saudi Arabia. The aim of the present study is to assess ACR TI-RADS as a reliable, noninvasive, and simple score in evaluation of thyroid nodules.

Among many of the US features of malignant thyroid nodules, ACR TI-RADS applied in this study includes only five sonographic characteristics, making it simple and applicable [8]. Solid composition of a nodule is the US feature with highest sensitivity for malignancy; all malignant lesions in current study were solid, whereas none of them were cystic or mixed in nature [16]. Similar to previous reports, the presence of irregular margin and microcalcification of the thyroid nodule represented important findings related to malignant nature of the nodule; in addition, none of the malignant nodules were taller than wider [17,18]. Yet, the presence of at least two of the sonographic features is more accurate in differentiating benign from malignant nodules than only one of these features [19].

The US character in the ACR TI-RADS are categorized 1 as benign, 2 as not suspicious, 3 as

Table 2 ACR Thyroid Imaging Reporting and Data Systems category versus Bethesda category

ACR TI-RADS category	Bethesda category					Total [*n* (%)]
	I	II	III	IV	V	
1	0	1	0	0	0	1 (0.8)
2	1	15	1	0	0	17 (13.8)
3	4	29	18	2	0	53 (43)
4	1	19	8	2	0	30 (24.4)
5	2	9	6	2	3	22 (18)
Total [*n* (%)]	8 (6.5)	77 (62.6)	30(24.4)	5 (4.1)	3 (2.4)	123

ACR, American College of Radiology; TI-RADS, Thyroid Imaging Reporting and Data Systems.

Table 3 Ultrasound feature of benign and malignant nodules

Ultrasound feature	Cytology		*P* value
	Benign (*N*=77)	Malignant (*N*=8)	
Nodule laterality			
Multiple	8	4	**0.01**
Solitary	69	4	
Composition			
Cystic	2	0	0.24
Mixed cystic and solid	26	0	
Solid	53	8	
Echogenicity			
Anechoic	1	0	0.16
Hyperechoic	66	4	
Hypoechoic	12	3	
Very hypoechoic	2	1	
Shape			
Wide than tall	76	8	0.86
Tall than wide	1	0	
Margin			
Smooth	74	5	**0.000**
Irregular	2	3	
Extrathyroid extension	1	0	
Echogenic foci			
Non or large	51	2	**0.009**
Macrocalcification	9	0	
Peripheral rim	6	1	
Punctate foci	11	5	

*P value <0.05 is considered significant.

Table 4 Thyroid Imaging Reporting and Data Systems classification versus fine-needle aspiration cytology results cross-tabulation

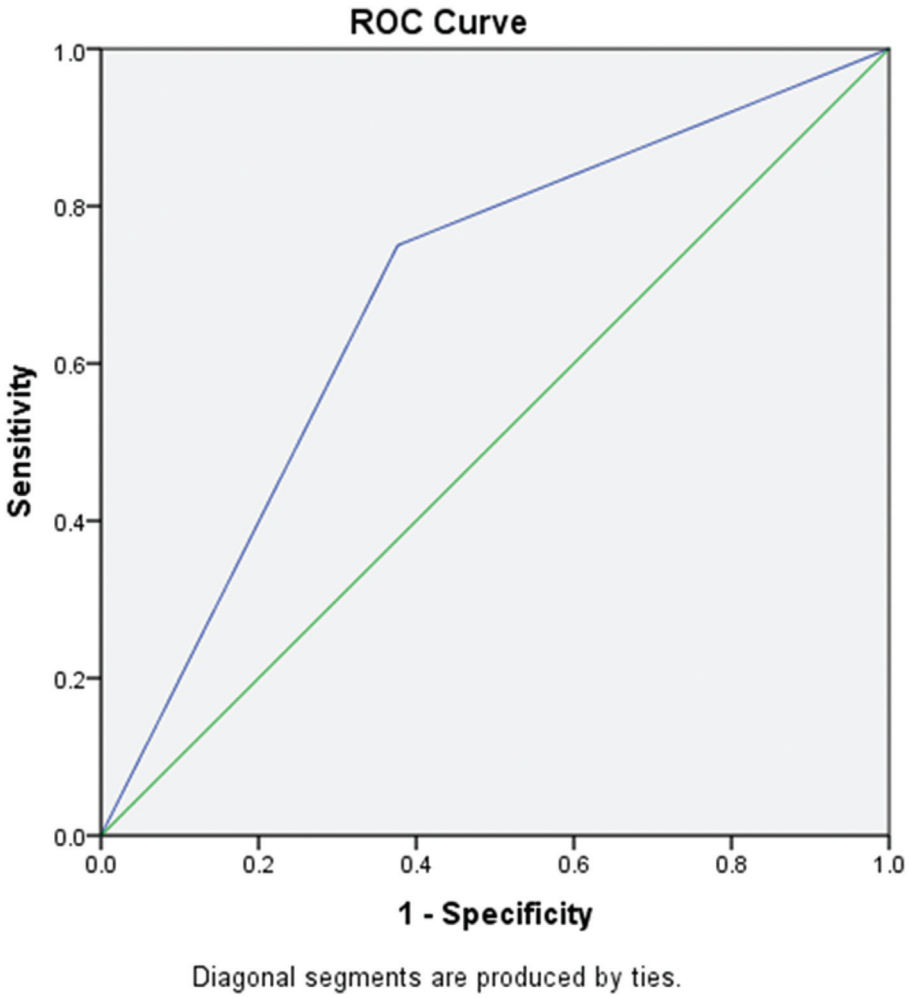
ACR TI-RADS category	FNAC results		Total
	Negative	Positive	
Negative			
Count	53	2	55
% of total	96.4	3.6	59.1
Positive[a]			
Count	32	6	38
% of total	84.2	15.8	40.9
Total			
Count	85	8	93
% of total	91.4	8.6	100.0

ACR, American College of Radiology; FNAC, fine-needle aspiration cytology; TI-RADS, Thyroid Imaging Reporting and Data Systems. [a]Positive means ACR TI-RADS 4–5.

minimally suspicious, 4 as moderately suspicious, or 5 as highly suspicious for malignancy [8]. Our study showed an increasing risk of malignancy with higher scored characteristic as described in ACR TI-RADS, as none of the nodules under ACR TI-RADS 1 and 2 turned out to be malignant. Similar to the white paper of the ACR TI-RADS Committee by Tessler and colleagues, which categorized the risk as less than 2% for TI-RADS 1 and 2, 2–5% for TI-RADS 3, 5–20% for TI-RADS 4, and more than 20% for TI-RADS 5, we found the risk of malignancy is 0% for TI-RADS 1 and 2, 3.7% for TI-RADS 3, 6.6% for TI-RADS 4, and 22.7% for TI-RADS 5. Mohanty *et al.* [20] reported the risk as 0, 0, 0, 30, and 56% for TI-RADS categories 1, 2, 3, 4, and 5, respectively.In our study, receiver operating characteristic analysis showed that ACR TI-RADS less than 3 could differentiate malignant thyroid lesions with an accuracy 68% and sensitivity, specificity, positive predictive value, and negative predictive value 75, 62.35, 15.7, and 96.3%, respectively. This goes with what was reported recently that positive predictive value for malignancy was 6.6 and 32% for TI-RADS 2 and 3 [21]. These institutional results suggest that TI-RADS could be a practical scoring system in predicting malignant thyroid lesions.

However, the interpretation of the results in this study requires further confirmation as the study has some limitations. First, the study was a retrospective in an institute that does not apply the TI-RADs in US reporting, which creates some limitation including cases without US images or incomplete study. Second, the study did not cover a large number of patients. Third, the ACR TI-RADS rating in the present study was limited by lack of standardized thyroid US scanning technique. Lastly, we depended on cytopathology results of FNAC and not on pathology results of the biopsy.

Figure 1



Receiver operating characteristic (ROC) curve of diagnostic performance of ACR TI-RADS compared with cytology shows an area under the curve of 0.687 (95% confidence interval: 0.501–0.873). TI-RADS, Thyroid Imaging Reporting and Data Systems.

Conclusion

In the current study, ACR TI-RADS, which collects the most important US features of thyroid lesion, had moderate sensitivity and specificity with fair accuracy in the assessment of the risk of malignancy of thyroid nodule. ACR TI-RADS 1 or 2 could defer FNAC for thyroid nodule. However, the accuracy of this system needs further evaluation by larger prospective studies.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Han XT, Yang Y, Peng B, CHEN Q. Thyroid nodule ultrasound image feature extraction technique based on TI-RADS. Comput Sci 2015; 42:126–130.

2 Ardakani AA, Gharbali A, Mohammadi A. Classification of benign and malignant thyroid nodules using wavelet texture analysis of sonograms. J Ultrasound Med 2015; 34:1983–1989.

3 Chow LS, Gharib H, Goellner JR, van Heerden JA. Nondiagnostic thyroid fine-needle aspiration cytology: management dilemmas. Thyroid 2001; 11:1147–1151.

4 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; 278:917–924.

5 Duan HM, Zhang TS, Chun-hua L, Jiahui W, Lihong W. Diagnostic value of ultrasound TI-RADS classification of thyroid cancer. Pract Med 2015; 20:3391–3394.

6 Vargas-Uricoechea H, Meza-Cabrera I, Herrera-Chaparro J. Concordance between the TIRADS ultrasound criteria and the Bethesda cytology criteria on the nontoxic thyroid nodule. Thyroid Res 2017; 10:1.

7 Horvath E, Majlis S, Rossi R, Franco C, Niedmann JP, Castro A, Dominguez M. *et al*... An ultrasonogram reporting system for thyroid nodules stratifying cancer risk for clinical management. J Clin Endocrinol Metab 2009; 94:1748–1751.

8 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; 14:587–595.

9 Cibas ES, Ali SZ. The 2017 Bethesda System for Reporting Thyroid Cytopathology. Thyroid 2017; 27:1341–1346.

10 Hong YJ, Son EJ, Kim EK, Kwak JY, Hong SW, Chang HS. Positive predictive values of sonographicfeatures of solid thyroid nodule. Clin Imaging 2010; 34:127–133.

11 Kim DW, Lee EJ, Jung SJ, Ryu JH, Kim YM. Role of sonographic diagnosis in managing Bethesda class III nodules. Am J Neuroradiol 2011; 32:2136–2141.

12 Kim DW, Lee YJ, Eom JW, Jung SJ, Ha TK, Kang T, *et al.* Ultrasound-based diagnosis for solid thyroid nodules with the largest diameter $<$5 mm. Ultrasound Med Biol 2013; 39:1190–1196.

13 Moon WJ, Jung SL, Lee JH, Na DG, Baek JH, Lee YH, *et al.* Thyroid Study Group, Korean Society of Neuro- and Head and Neck Radiology. Benign and malignant thyroid nodules: US differentiation multicenter retrospective study. Radiology 2008; 247:762–770.

14 Lee MJ, Kim EK, Kwak JY, Kim MJ. Partially cystic thyroid nodules on ultrasound: Probability of malignancy and sonographic differentiation. Thyroid 2009; 19:341–346.

15 Park JY, Lee HJ, Jang HW, Kim HK, Yi JH, Lee W, Kim SH. A proposal for a thyroid imaging reporting and data system for ultrasound features of thyroid carcinoma. Thyroid 2009; 19:1257–1264.

16 Frates MC, Benson CB, Charboneau JW, Cibas ES, Clark OH, Coleman BG, *et al.* Management of thyroid nodules detected at US: Society of Radiologists in US consensus conference statement. Radiology 2005; 237:794–800.

17 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. Int J Med Radiol 2011; 260:892.

18 Yunus M, Ahmed Z. Significance of ultrasound features in predicting malignant solid thyroid nodules: need for fine-needle aspiration. J Pak Med Assoc 2010; 60:848–853.

19 Frasoldati A, Valcavi R. Challenges in neck ultrasonography: lymphadenopathy and parathyroid glands. Endocr Pract 2004; 10:261–268.

20 Mohanty J, Sanket XX, Mishra P. Role of ACR-TIRADS in risk stratification of thyroid nodules. Int J Res Med Sci 2019; 7:1039–1043.

21 Chandramohan A, Khurana A, Pushpa BT, Manipadam MT, Naik D, Thomas N, Abraham D, Paul MJ. Is TIRADS a practical and accurate system for use in daily clinical practice?. Indian J Radiol Imaging 2016; 26:145–152.