Original article

New Indian Journal of Surgery
Volume 12 Number 4/ October–December 2021
DOI: https://dx.doi.org/10.21088/nijs.0976.4747.12421.8

Risk Stratification of Thyroid Nodules Comparitive Study Between Ti-Rads, Cytology and Histopathology

K Lokesh[1], B Yochitha[2]

Author's Affiliation: [1]Assistant Professor Department of General Surgery, Government Medical College, Andhra Pradesh 515001, [2]Senior Resident, Department of General surgery, Hyderabad 500001, Andhra Pradesh, India.

How to cite this article:
K Lokesh, B Yochitha/Risk Stratification of Thyroid Nodules Comparitive Study Between Ti-Rads, Cytology and Histopathology/New Indian J Surg. 2021;12(4):257–263.

Introduction

A thyroid nodule is defined as a lesion that is distinct and may be differentiated from the surrounding thyroid parenchyma by clinical examination, Ultrasound or other sensitive imaging modalities.[1] The prevalence varies from 4 to 7% by just palpation[2,3] When patients were assessed by ultrasound, the prevalence of a thyroid nodule was as high as 80% among the iodine-deficient parts of India.[4] This is much higher than diagnosed on clinical examination. The nodules discovered with imaging studies are called "thyroid incidentalomas.[5,6] The correlation between imaging methods and the prevalence reported at surgery and autopsy ranges between 50 and 65%.[7]

The importance of the evaluation of thyroid nodules is the possibility of malignancy. The incidence of thyroid cancer is low (1-1.8 per 100,000).[8] There are vast differences in the reported percentage of malignancy among the clinically or thyroid nodules detected by radiologically.

The average prevalence of malignancy rates across the world in thyroid nodules, from 4.0 to 6.5% on evaluation by an invasive procedure.[9,10] There are well-established ultrasound findings that differentiate benign and malignant thyroid nodules.[11,12,13] There are several classification systems which categorise thyroid nodules according to the risk of cancer.[14,15,16]

The ultrasonographic characteristics of a thyroid nodule associated with a higher incidence of malignancy include hypo echogenicity, increased intra-nodular vascularity, irregular margins, micro calcifications, absent halo, and a taller than-wide shape measured in the transverse dimension.[17]

Several benign and malignant ultrasound gray scale and Doppler features have emerged in the last decade that may be used in various ways to assign probabilities, along with another method based on the Breast Imaging Reporting and Data System (BIRADS), Thyroid Imaging Reporting and Data Systems (TIRADS) of thyroid nodules have been proposed for risk stratification.[18]

Fine-needle aspiration (FNA) is considered a cost-effective method and accurate for evaluating thyroid nodules, for the differential diagnosis of these thyroid nodules, with high diagnostic sensitivity and specificity.[19,20,21]

The purpose of the current research is to evaluate the reliability of TIRADS in determining the malignancy in the thyroid nodules that invasive cytology and surgery can be avoided in the low-risk group.

Corresponding Author: B Yochitha, Senior Resident, Department of General surgery, Hyderabad 500001, Andhra Pradesh, India.

E-mail: buddiyochita@gmail.com

Materials and Methods

Type of Study: Prospective observational study.

Study Setting: Department of General Surgery, Tertiary Care Centre.

StudyPeriod: November 2017 to September 2019.

Study Sample: 77 cases admitted in General Surgery Ward with nodular thyroid enlargement and underwent thyroidectomy.

Methodology

Demographic data and risk factors for thyroid malignancy, along with the history of the patient were recorded in the proforma. All selected cases subjected to Ultrasonography, and ACR-TIRADS score obtained. FNAC was done and reported according to the Bethesda system of Cytopathology reporting.

Patients posted for thyroidectomy, and Histopathological report of the specimen collected. In the end, TIRADS score compared with the FNAC, and HPE reports in assessing or predicting the malignancy in a thyroid nodule.

Results

Table 1: Age distribution in the study population.

Age in years	No of Cases	Percentage
13-20	1	2
21-30	10	13
31-40	23	28
41-50	24	31
51-60	12	16
61-70	5	7
>70	2	3
Total	77	100

Table 2: Sex distribution in the study population.

Sex	No of Cases	Percentage
Male	10	13
Female	67	87
Total	77	100

Table 3: Composition of the Thyroid Nodules.

Composition	Score	No of Cases	Percentage
Cystic/spongiform	0	0	0
Mixed cystic & solid	1	58	75
Completely solid	2	19	25

Table 4: Echogenicity of the Thyroid Nodules.

Echogenicity	Score	No of Cases	Percentage
Anechoic	0	8	10
Hyper or isoechoic	1	47	61
Hypoechoic	2	22	29
Very hypoechoic	3	0	0

Table 5: Shape of the Thyroid Nodules.

Shape	Score	No of Cases	Percentage
Wider than tall	0	67	87
Taller than wide	3	10	13

Table 6: Margin of the Thyroid Nodules.

Margin	Score	No of Cases	Percentage
Smooth /ill-defined	0	71	92
Lobular /irregular	2	6	8
Extra thyroidal extension	3	0	0

Table 7: Echogenic foci in the Thyroid Nodules.

Echogenic foci	Score	No of Cases	Percentage
None or comettail artefact	0	44	57
Macrocalcifications	1	8	10
Peripheral rim calcification	2	1	2
Punctate echogenic foci	3	24	31

Table 8: TIRADS score for the Thyroid Nodules.

TIRADS	Grade	No of Cases	Percentage
Benign	TR1	0	0
Not suspicious	TR2	32	42
Mild suspicious	TR3	16	21
Moderately suspicious	TR4	12	15
Highly suspicious	TR5	17	22

Table 9: FNAC of the Thyroid Nodules.

FNAC	Bethesda Class	No of Cases	Percentage
Non diagnostic	I	0	0
Benign	II	52	68
AUS/FLUS	III	1	2
Suspicious of follicular neoplasm	IV	5	6
Suspicious for malignancy	V	7	9
Malignant	VI	12	15

Table 10: Histopathology Report of Thyroidectomy specimen.

Histopathology Report	No of Cases	Percentage
Nodular Goitre	44	57
Hashimotos Thyroiditis	9	12
Papillary Carcinoma	18	23
Follicular Adenoma	4	5
Follicular Carcinoma	2	3

Table 11: Comparison of TIRADS, FNAC and Histopathology Reports.

TIRADS Grade		FNAC			HPE	
		Benign	Malignant	Follicular lesion	Benign	Malignant
TR1	0	-	-	-	-	-
TR2	32 (41.5%)	32 (100%)	-	-	32 (100%)	-
TR3	16 (21%)	15 (93.7%)	1 (6.3%)	-	15 (93.7%)	1 (6.3%)
TR4	12 (15.5%)	5 (41.7%)	2 (16.6%)	5 (41.7%)	9 (75%)	3 (25%)
TR5	17 (22%)	1 (5.8%)	16 (94.2%)	-	1 (5.8%)	16 (94.2%)

Table 12: Comparison of TI-RADS with FNAC.

	FNAC Malignant (Positive)	FNAC Benign (Negative)	Total
TR4, TR5 (Positive)	23	6	29
TR2, TR3 (Negative)	1	47	48
Total	24	53	77

Table 13: Comparison of TIRADS with histopathology.

	HPE Benign	HPE Malignant	Total
TR2, TR3 (Negative)	47	1	48
TR4, TR5 (Positive)	10	19	29
Total	57	20	77

Discussion

Initial analysis of thyroid nodules based on the following.

- Proper history, along with a clinical examination of the patient,
- Lab tests –thyroid function tests,
- Thyroid USG, and
- USG-guided FNAC based on TI-RADS features.[22]

It is similar to the triple assessment of the breast lumps. Unlike breast lumps, TI-RADS US features are still not routinely used in several medical institutes.[23]

The accessibility of TI-RADS and validation of this USG classification system by the ACR permit a precise both clinical and pathological correlation. As noted from the previous studies, a robust clinical and pathological correlation will guide in defining the risk of malignancy and proper direct management of thyroid lesions.[24-27] However, a general agreement not yet mentioned gives the difficulty in reproducing different classification systems or even the low correlation between the USG reports and FNAC.[28]

Of all the systems, the classification proposed by ACR-TIRADS is simple and similar to BIRADS system, which is in use for many years and is familiar to many radiologists. Therefore, we assessed thyroid nodules based on ACR-TIRADS.[29-38]

Age and Sex Distribution

In this study, the peak incidence noted in the age group of 41-50 years. The youngest patient was 18yrs, and the eldest was 72 yrs. In this study, 67 were female, and10 were males. A female to male's ratio in the study was 6.7:1.

Abdelkader et al.[39] studied 100 patients; 22 males and 78 females with mean age 43.7 ±11.5; range: 22-60 years.

In Periakaruppan, et al., [40]A total of 184 patients included in the study, out of which females are 156. These nodules mostly found among 30-60 years of life. The patients in this age group are137 patients, about 75% of our study population.

In Chandramohan, et al.[41] Out of 272 nodules, 154 benign nodules (119 were females, 35 were males) and among 118 malignant nodules (75 were females, 43 were males). Malignancy was more common among male patients presenting with a thyroid nodule (P=0.01).

When comparing our results with the results of a study done by Singaporewalla et al.[42] the US of thyroid nodules in our study had a comparable sensitivity in predicting malignancy (82.45% versus 71.5%)and specificity (95% versus 84%). We also had a better NPV of TI-RADS score predicting malignancy (65.5% versus 91.5%) and PPV 97.92%.

In our study, there were no cases with TR1. Among the 32 cases in TR2 FNAC and histopathology was proved to be benign in all the 100% cases. 16 cases were in TR3 among them FNAC and histopathology showed benign aetiology in 15 and malignant features in 1 case subsequently. In 12 cases with TR4 5 were benign, two were malignant, and 5 showed follicular lesions on FNAC, and on histopathology 9 turned out to be benign lesions, and three were of malignancy. Among the 17 cases in TR5 16 were malignant and one was benign on FNAC and histopathology.

Among 77 cases, of a total 48 cases which labeled as benign (mostly TR2, TR3), 47 cases are also proven to be benign, and only one case turned out as malignant on FNAC. Of a total of 29 cases which labelled as malignant (TR 4, TR 5) on TR-RADS, 23 are proven to be malignant on FNAC, and only six turned out as benign on FNAC.

According to these findings, TI-RADS have a sensitivity of about 95.83%, Specificity of approximately 88.67%, the positive predictive value of approximately 79.31%, the negative predictive value of approximately 97.92% compared with FNAC (cytology).

Among 77 cases, of a total 48 cases which labeled as benign (mostly TR2, TR3), 47 cases are also proven to be benign, and only one case turned out as malignant on HPE. Of a total of 29 cases which labeled as malignant (TR4, TR5) on TR-RADS, 19 are proven to be malignant, and 19 turned out as benign on HPE.

According to these findings, TI-RADS have a sensitivity of about 82.45%, Specificity of about 95%, positive predictive value (PPV) of approximately 97.92%, negative predictive value (NPV) of approximately 65.52% compared with HPE.

In Singaporewalla et al[42] study, they had 20 patients classified as TI-RADS 5 (malignant on the US), FNAC biopsy showed only 12 confirmed as malignant, and the remaining were benign. That gives them a 60% accuracy of US in predicting malignancy. Similarly, in this study, they found that among the 14 cases categorized as TIRADS 5, 10/14 cases had an FNAC biopsy established as cancer (71.4% accuracy).

Ultrasound impression of thyroid nodules had lower sensitivity in predicting malignancy (70.6% compared to 88%) but higher specificity (90.4% compared to 49%). They also had a higher positive and negative predictive value of TIRADS score predicting malignancy as well (60% compared to 49%, and 93.8% compared to 88%, respectively). Accuracy was 83% overall. In this study, the risk of malignancy for the different TIRADS categories was 0% (TIRADS2), 9.5% (TIRADS 3), 33.3% (TIRADS 4) and 60% (TIRADS 5).

Abdelkader et al.[39] study in 55 patients with thyroid nodules of probably benign (TI-RADS3) nature and FNA cytology established the same in 45/55 patients showing 82% concordance rate between US and FNAC.

Among the 31 cases that categorized as TI-RADS4 (indeterminate), 8/31 cases were benign on FNAC (Bethesda II), 1/31 cases had an FNAC biopsy established as cancer. Remaining 22/31 patients were under Bethesda III, IV, and V, giving a 70.9% concordance rate between the US and FNAC.

Among the 14 cases that categorized as TI-RADS 5 (malignant on the US), 2/14 patients were benign on FNAC biopsy (false-positive of the US), 5/14 cases were suspicious on FNAC (Bethesda IV), and 7/14 cases had an FNAC biopsy established as cancer giving a 50% concordance between the US and FNAC. From the previous results, the overall concordance rate between US TI-RADS and Bethesda is 67.6%.

The final concordance rate of US TI-RADS with the final histopathological results for predicting malignancy was 75.4% with a sensitivity 76.9% and specificity 91.3%, PPV 71.4%, and NPV 76.4%. The concordance rate of FNAC with the final HPE findings for identifying malignancy was 95% with a sensitivity and specificity of 81.8% and 98% respectively, PPV 90%, and NPV 96%.

In Chandramohan, et al.[44] study in 168 cases, The PPV for malignancy of TIRADS 2, 3, 4a, 4b, 4c, and 5 categories was 6.6%, 32%, 36%, 64%, 59%, and 91%, respectively. In conclusion, the PPV for malignancy was high for TIRADS category five and 4c nodules. Reassigning TIRADS category 4a nodules as TIRADS3 will improve the PPV and specificity of TIRADS. In Kwak et al.[45] describes 0%, 1.7%, 3.3%, 9.2%, 44.4–72.4%, and 87.5% risk of malignancy for TIRADS 2, 3, 4a, 4b, 4c, and 5 categories, respectively. However, in a subsequent retrospective validation study, the authors found a 7.3% and 8.3, 96.6% risk of malignancy in TIRADS 3 and TIRADS 4,5 categories of thyroid nodules.

According to Periakaruppan, et al.[40], study out of the 184 nodules, 117 categorised under TIRADS 2, none turned out to be under Bethesda IV or higher, which means none of the nodules turned out to be malignant. Thirteen classified under TIRADS4, and 9 as TIRADS 5 category. Among the 45 nodules labelled as TIRADS 3, 42 nodules are Bethesda II and one nodule each in Bethesda I, III, and IV, on FNAC respectively.

Few nodules which appeared suspicious on USG are classified as TIRADS 4 and TIRADS5 but turned out to be benign in FNAC according to Bethesda classification. Considering all nodules, the proportion of nodules being malignant classified as TIRADS2 were 0.0, TIRADS3 were 7.7, TIRADS 4 was 38.4, and TIRADS5 was 53.9%. In this study, sensitivity is 92.3%, specificity is 94.15%, and PPV is 54.54%, and NPV is 99.38%. A significant association is noted between TIRADS and Bethesda system of classification (P<0.001). In a study by Stephanie A. Fish43, a total of 832 nodules evaluated with ultrasound before FNA cytology. Seventy-nine nodules measured lowerthan 1cm and removed from the study. Another 251 nodules excluded due to indeterminate cytology results. The final study included 502 nodules in 477 patients.

Thirty-six (7.2%) nodules determined to be malignant. In general, strictly following the recommendations from the risk-stratification systems decreased the number of FNAs to between 17.1% and 53.4%. The most effective method was ACR TIRADS, which would have reduced the biopsy number by greater than half (53.4%) with 2.2% false-negative rate. The false-negative rate was due to nodules with a final diagnosis of malignancy, but no biopsy recommendation based on the risk-stratification system. Many more biopsies recommended as most of the systems had similar discriminatory capacities to identify malignancy. K-TIRADS was the poor performer, as it reduced the number of biopsies by only 17.1%. Eleven nodules diagnosed as malignant would have misclassified as not requiring FNA by atleast one of the TIRADS systems. All five systems missed three cancers; which were either isoechoic or hyperechoic and had no other suspicious features. The best performance is by ACR TIRADS by classifying more than half of FNA cytology as unnecessary with only 2.2% false-negative rate.

Conclusion

In conclusion, from the study, it was made out that the PPV for malignancy was high for TIRADS category 5 and 4 nodules. TIRADS is a straight forward and practical method of assessing thyroid nodules and can be used in practice as the overall agreement between observers for assigning TIRADS category was substantial.

Acknowledgement

Dr. Suhas, Dr. VV Subramanyam

Conflict of Interest: Nill

References

1. Hossein Gharib, Enrico Papini, Jeffrey R.Garber, DanielS. Duick, R. MackHarrell, Laszlo Hegedüs, Ralf Paschke, Roberto Valcavi, and Paolo Vitti (2016) American association of clinical endocrinologists, American college of endocrinology, and Associazione Medici endocrinology medical guidelines for clinical practice for the diagnosis and management of thyroid nodules – 2016 UPDATE. Endocrine Practice:May2016,Vol.22,No. Supplement1,pp.1-60.
2. SingerPA, CooperDS, DanielsGH, GreenspanFS, LadensonPW. The treatment guidelines for patients having thyroid nodules and well-differentiated thyroid cancer. American Thyroid Association. ArchIntern,Med.1996;156:2165–72.
3. MazzaferriEL. Management of a solitary thyroid nodule. N EnglJMed. 1993;328:553–9.
4. BrahmbhattSR, BrahmbhattRM, BoyagesSC. Impact of protein-energy malnutrition on thyroid size in an iodine-deficient population of Gujarat (India): Is it an aetiological factor for goitre? Eur JEndocrinol.2001;145:11–7.
5. MazzaferriEL. Management of a solitary thyroid nodule. N Engl J Med. 1993;328:553–9.
6. EzzatS, SartiDA, BraunsteinGD, CainDR. Named Thyroid Incidentalomas: Prevalence of Palpation and Ultrasonography. Arch Intern Med. 1994; 154(16):1838–1840.
7. MortensenJD, BennettWA, WoolnerLB. Gross and microscopic findings in Clinically normal thyroid glands. The Journal of Clinical Endocrinology & Metabolism.J Clin Endocrinol Metab.1955;15:1270–80.
8. UnnikrishnanAG, MenonUV. Thyroid disorders in India: An epidemiological perspective. Indian JEndocrinol Metab.2011;15(Suppl2):S78–81
9. Sabino de Matos, P., Ferreira, A.P.C. & Ward, L.S. EndocrPathol (2006) 17:165.
10. Kovacs GL, Gonda G, Vadasz G, Uhrin K, Gorombey Z, et al., Ludmany E. Epidemiology of thyroid microcarcinoma found in autopsy series conducted in areas of different iodine intake. Thyroid.2005;15:152–7.

11. Choi N, Moon WJ, Lee JH, Baek JH, Kim DW, Park SW. Ultrasonographic findings of MTC: Differences according to tumour size and correlation with fine-needle aspirationresults. ActaRadiol.2011;52:312–6.
12. Hong YJ, Son EJ, Kim EK, Kwak JY, Hong SW, Chang HS. Positive predictive values of sonographic features of the solid thyroid nodule. ClinImaging.2010;34:127–33.
13. Kim DW, Lee EJ, Jung SJ, Kim YM, Ryu JH. Role of US diagnosis in managing Bethesda class III nodules. AJNRAm JNeuroRadiol.2011;32:2136–41.
14. ParkJY, LeeHJ, JangHW, YiJH, LeeW, etal., KimHK. Aproposal for a thyroid imaging reporting and data system for ultrasound features of thyroid carcinoma. Thyroid.2009;19:1257–64.
15. Horvath E, Majlis S, Rossi R, Niedmann JP, Castro A, et al., Franco C. An ultrasonogram reporting system for thyroid nodules stratifying cancer risk for clinical management.JClinEndocrinolMetab.2009; 94:1748–51.
16. Kwak JY, Jung I, Baek JH, Choi N, Baek SM, Choi YJ, et al. ; Korean Society of Thyroid Radiology (KSThR). Image reporting and characterisation system for Ultrasound features of thyroid nodules: Multicentric Korean retrospective study. Korean J Radiol.2013;14:110–7.
17. Choi N, Moon WJ, Lee JH, Baek JH, Kim DW, Park SW. Ultrasonographic findings of MTC: Differences according to tumour size and correlation with fine-needle aspiration results. ActaRadiol.2011;52:312–6.
18. BrahmbhattSR, BrahmbhattRM, BoyagesSC. Impact of protein-energy malnutrition on thyroid size in an iodine-deficient population of Gujarat (India): Is it an aetiological factor for goitre? Eur JEndocrinol.2001;145:11–7.
19. Revised ATA management guidelines for patients with thyroid nodules, differentiated thyroid cancer. David S. Cooper, Gerard M. Doherty, Richard T.Kloos,BryanR.Haugen,SusanJ,StephanieL.Lee. Mandel,ErnestL.Mazzaferri, Furio Pacini, Bryan McIver, Martin Schlumberger, David L. Steward, and R.Michael Tuttle, StevenI. Sherman.Thyroid 200919:11,1167-1214.
20. Pinchot SN, Al-WagihH, SchaeferS, ChenH, SippelR. Accuracy of fine-needle aspiration biopsy for predicting neoplasm or carcinoma in thyroid nodules 4 cmorlarger. ArchSurg2009;144(7):649–655.
21. Yoon JH, Moon HJ, Kwak JY, Kim EK. Inadequate cytology in thyroid nodules: should we repeat aspiration or follow-up?Ann Surg Oncol 2011;18(5):1282–1289.
22. SrinivasMN, AmoghVN, GautamMS, etal. A Prospective Study to Evaluate the Reliability of Thyroid Imaging Reporting and Data System in Differentiation between Benign and Malignant Thyroid Lesions. J Clin Imaging Sci. 2016;6:5. Published2016Feb26.DOI:10.4103/2156-7514.177551.
23. Chandramohan A, Khurana A, Pushpa B, Naik D, Manipadam M, Thomas N,Abraham D and Paul M: (2016) Is TIR-ADS a practical and accurate system for use in daily clinical practice? IndianJ Ra diolImaging.2016;26(1):145–152.
24. HoangJ,LangerJ,MiddletonW,CronanJ,Hamm ersL,GrantE,BerlandL,andTesslerF:Managing incidental thyroid nodules detected on imaging: white paper of the ACR Incidental Thyroid Findings Committee. Journal of the American College of Radiology: JACR. 2015;12 (2):143-50.
25. ParkJ,LeeH,JangHKimH,HyuckJ,LeeWandKimS :A proposal for a thyroid imaging reporting and data system for ultrasound features of thyroid carcinoma.Thyroid.2009; 19 (11):1257–1264
26. Moifo B, Takoeto E, and Tambe J: Reliability of thyroid imaging reporting and data system (TIRADS) classification in differentiating benign from malignant thyroid nodules. Open J Radiol.2013; 3:103–107.
27. Hossein G, Enrico P, Jeffrey R, Mack H, Daniel S, Laszlo H, et al.: American Association of Clinical Endocrinologists, ACE, and Associazione Medici Endocrinology Medical Guidelines for Clinical Practice for the Diagnosis, Management of Thyroid Nodules-2016 Update. EndocrPract.2016;22(5):622–639.
28. Paschke R, Hegedüs L, Alexander E, Papini E, Valcavi R, Gharib H. Thyroid nodule guidelines:Agreement, disagreement and need for future research.Nat Rev Endocrinol2011;7:354-61.
29. Hong YJ, Son EJ, Kim EK, Hong SW, Kwak JY, Chang HS. Positive predictive values of sonographic features of a solid thyroid nodule. ClinImaging2010;34:127-33.
30. Kim DW, Lee EJ, Jung SJ, Kim YM, Ryu JH. Role of US diagnosis in managing Bethesda class III nodules .AJNRAm JNeuroRadiol2011;32:2136-41.
31. KimDW, LeeYJ, EomJW,JungSJ,HaTK,KangT. ultrasound-based diagnosis for solid thyroid nodules with the largest diameter <5 mm. Ultrasound Med Biol2013;39:1190-6.
32. KimDW, ParkJS, ChooHJ,InHS, JungSJ, RyuJH. Ultrasound based diagnostic classification for a solid and partially cystic thyroid nodule. AJNR AmJNeuroradiol2012;33:1144-9.
33. Kim EK, Park CS, Chung WY, Kim DI, Oh KK, Lee JT, et al. New sonographic criteria for recommending fine needle aspiration biopsy of nonpalpable solid nodules of the thyroid.AJR Am JRoentgenol2002;178:68791.
34. Moon WJ, Jung SL, Lee JH, Baek JH, Na DG, 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. Radiology2008;247:762-70.

35. Lee MJ, Kim EK, Kim MJ, Kwak JY. Partially cystic thyroid nodules on the US: Probability of malignancy and sonographic differentiation. Thyroid2009;19:3416.
36. ParkJY,LeeHJ,JangHW,YiJH,KimHK,LeeW,etal. Aproposal for a TIRADS for ultrasound features of thyroid carcinoma.Thyroid2009;19:125764.
37. HorvathE,MajlisS,RossiR,NiedmannJP,FrancoC,CastroA,etal.An ultrasonogram reporting system for thyroid nodules stratifying cancer risk for clinical management. J Clin EndocrinolMetab2009;94:1748-51.
38. Kwak JY, Jung I, Baek JH, Choi N, Baek SM, Choi YJ, et al.; Korean Society of Thyroid Radiology (KSThR). Image reporting and characterisation system for ultrasound features of thyroid nodules: Multicentric Korean retrospective study. KoreanJ Radiol2013;14:110-7.
39. Preoperative Evaluation of Thyroid Nodules: A Prospective Comparing the accuracy of Ultrasound (TI-RADS) Versus the FNAC Bethesda System in Relation to the Final Postoperative Histopathological Diagnosis https://www.pacificejournals.com/2110/1594.
40. Periakaruppan G, SeshadriK, Vignesh KrishnaGM, MandavaR, SaiV, Rajendiran S. Correlation between ultrasound-based TIRADS and Bethesda system for reporting thyroid-cytopathology: a 2-year experience at a tertiary care center in India. IndianJEndocrMetab2018;22:651-5.
41. Chakravarthy NS, Chandra Mohan A, Prabhu AJ, GowriM, Mannam P, Shyamkumar NK, et al. US-guided FNA cytology along with clinical and radiological features in predicting thyroid malignancy in nodules ≥1 cm. Indian JEndocrMetab2018;22:597-604.
42. Singaporewalla, R M, et al. Clinical Pathological Correlation of Thyroid Nodule Ultrasound and Cytology Using the TIRADS and Bethesda Classifications.WorldJournalof Surgery,U.S. National LibraryofMedicine,July2017.
43. Fish, Stephanie A. "ACR TIRADS is Best to decreases the Number of Thyroid Biopsies and Maintain Accuracy."Clinical Thyroidology,vol.31,no.3,2019,pp.113-116.,DOI:10.1089/ct.2019;31.113-116
44. Chandramohan A, Khurana A, Pushpa B, Naik D, Manipadam M, Thomas N,Abraham D and Paul M: (2016) Is TIR-ADS a practical and accurate system for use in daily clinical practice? IndianJ RadiolImaging.2016;26(1):145–152.
45. Kwak JY, Han KH, Yoon JH, Son EJ, Moon HJ, Park SH, et al. Thyroid imaging reporting and data system for US features of nodules: A step in establishing better stratification of cancer risk. Radiology2011;260:8929.