Role of Ultrasound and Magnetic Resonance Imaging in Assessment of Thyroid Nodules

[1]DoaaLotfi Hassan Abd-Elmageed, [2]EngyFathiTantawy, [3]Amr Osama Khalil, [4]HebaAbd-ElmonemElsayed

Abstract

Background: Thyroid nodules are very commonly observed on thyroid imaging. A minority of thyroid nodules is malignant; even so, many invasive diagnostic procedures are performed to discriminate between benign and malignant nodules.The aim of this work was to determine the great role of Ultrasonography and Magnetic Resonance Imaging in assessment of thyroid nodules and to reduce cost-effectiveness by decreasing number of unnecessary fine needle aspiration cytology (FNAC).**Methods**: All patients in the study were subjected to full history taking and clinical examination. Gray-scale Ultrasound and color Doppler examination were done to all patients. The nodules were classified into TIRADS categories. According to TIRADS categories, they were classified into group (A) and group (B).**Results:**12patients with 16 nodules were subjected to MRI examination. 11 nodules showed free diffusion with higher ADC values and 5 nodules showed restricted diffusion with lower ADC values. On comparison with histopathological examination, most of the nodules with restricted diffusion and lower ADC values were proven to be malignant. So DWI-MRI has high sensitivity (91.7%) and specificity (100%) in differentiating benign and malignant thyroid nodules.**Conclusion:** DW-MR imaging has a useful role in the evaluation of the thyroid nodules and post thyroidectomy recurrent nodules providing a good determining tool by the measurement of the ADC value. Contrast enhancement could provide complementary data for differentiation.

Key words: Ultrasonography- Magnetic Resonance Imaging- thyroid nodules.

I. Introduction:

Ultrasonography (US) is widely used in the assessment of the thyroid gland. Among the different pathologies that can be depicted and characterized by US are nodules. Nodules may be benign or malignant. Some studies have shown that less than 10% of thyroid nodules are malignant and that thyroid US depicts nodules in up to 50% to 67% of the population [(1,2)].

Although ultrasound (US) is widely used to detect thyroid nodules and determine their malignant potential, the US features and index of each grade of Thyroid Imaging Reporting and Data System (TI-RADS)

[1]*M.B.B.ch, Zagazig University, Radiology Resident atMit-Ghamr Oncology Center, Ministry of Health*
[2]*Assistant professor of Radio-diagnosis, Faculty of Medicine – Zagazig University*
[3]*Lecturer of Radio-diagnosis, Faculty of Medicine – Zagazig University*
[4]*Assistant professor of Radio-diagnosis,Faculty of Medicine – Zagazig University.*

remain controversial [3,4].US guided fine needle aspiration biopsy (FNAB) is widely used for the diagnosis of thyroid nodules [4]. However, up to 7% of the nodules yield non diagnostic cytology and an additional 15-30% of fine needle aspiration cytology (FNAC) show an indeterminate cytology [4,5].

MRI signal intensity characteristics of thyroid lesions can enable us to differentiate the different types of thyroid lesions, potentially improving clinical management [3].

Diffusion-weighted magnetic resonance imaging (DW-MRI) is a recent addition to the MR sequences. It can provide qualitative and quantitative functional information concerning the microscopic movements of water at the cellular level [6].

The study aimed todetermine the efficiency of US, Doppler and MRI in assessment of thyroid nodules using pathological examination as a golden standard.

II. Patients and Methods

Patients:

This prospective study was conducted at Radiology Department; Zagazig University during the period from November 2018 to February 2020. The study included 62 patients (7 males and 55 females), their ages ranged from 18 to 72 years old with the mean of age 43.19 ± 15.11. Informed consent had been taken from all the participants in this study.

This study was approved by our Institutional Review Board (IRB).The patients were divided into two groups according to TIRADS categories of their thyroid nodules ; **Group A**, involving fifty patients who were classified as TIRADS 2,3 (subjected to US and histopathological examinations) &**Group B**, involving twelve patients who were classified as TIRADS 4A,4B,5 and patients with recurrent operative bed nodules after prior total thyroidectomy (subjected to US , MRI and histopathological examinations).

Methods:

I. All Patients in this study were subjected to:

1. Complete history taking.

2. Full clinical examination**.**

3. Ultrasonography and color Doppler evaluation**.**

II. MRI:

III. US-guided FNAC: Thirty-five patients were subjected to FNAC about four weeks after radiological examination.

STATISTICAL ANALYSIS

A collected throughout history, basic clinical examination, laboratory investigations and outcome measures coded, entered and analyzed using Microsoft Excel software. Data were then imported into Statistical Package for the Social Sciences (SPSS version 20.0) (Statistical Package for the Social Sciences) software for analysis. According to the type of data qualitative represent as number and percentage, quantitative continues group represent by mean ± SD, the following tests were used to test differences for significance;. difference and association of qualitative variable by Chi square test (X^2) . Differences between quantitative independent groups by t test, correlation by Pearson's correlation or Spearman's . A receiver operating characteristic (ROC). P value was set at <0.05 for significant results &<0.001 for high significant results. Data were collected and submitted to statistical all the following statistical tests and parameters were used .

III. Results

The current study included **73** nodules out of **62** patients who fulfilled the inclusion criteria selected for the study. There were **52** patients with solitary thyroid nodule and **10** patients with multiple nodules (**1** patient had **3** nodules and **9** patients had **2** nodules).

Male constituted 11.3% of the studied patients with age ranged from 18 to 72 years.

Table (1): Distribution of the studied patients according to the demographic characteristics:

	N=62	%
Gender		
• **Female**	55	88.7
• **Male**	7	11.3
Age (years):		
• **Mean ± SD**	43.19 ± 15.11	
• **Range**	18 – 72	

Table (2): Performance of a well-defined margin in the diagnosis of benign nodules in all patients:

Ultrasonography margin	Pathology		Total
	Benign	Malignant	
• Well defined	54	2	56
• Ill defined& irregular	13	4	17

Total	67	6	73

	Value
Sensitivity	80.6
Specificity	33.3
PPV	88.3
NPV	13.3
Accuracy	76.7

A well-defined margin in the prediction of benign nature of nodule showed a sensitivity of 80.6%, a low specificity of 33.3%, a positive predictive value of 88.3% and a negative predictive value of 13.3%. Yet it had an accuracy of 76.7%

Table (3): Performance of absent hypoechoic halo in the diagnosis of benign nodules in all patients:

Ultrasonography hypo-echoic halo	Pathology		Total
	Benign	**Malignant**	
Absent •	55	4	59
Present •	12	2	14
Total	67	6	73

	Value
Sensitivity	82.1
Specificity	33.3

PPV	93.2
NPV	14.3
Accuracy	78.1

Absent hypo echoic halo in the prediction of benign nature of nodule showed a sensitivity of 82.1%,a low specificity of 33.3%, a positive predictive value of 93.2% and a negative predictive value of14.3%. Yet it had an accuracy of 78.1%.

Table (4): Performance of TIRADS 2, 3 and 4a in the diagnosis of benign nodules in all patients:

Ultrasonography TIRADS	**Pathology**		**Total**
	Benign	**Malignant**	
• **T 2, 3, 4a**	58	2	60
• **T4b+5+recurrent**	9	4	13
Total	67	6	73

	Value
Sensitivity	86.6
Specificity	66.7
PPV	96.7
NPV	30.8
Accuracy	84.9

The sensitivity of TIRADS 2,3 and 4a in the prediction of benign nature of nodule was 86.6%. It showed a specificity of 66.7%, a positive predictive value of 96.7% and a negative predictive value of 30.8%. Yet it had an accuracy of 84.9%.

IV. Discussion

Erdem et al.,[7] included 27 cases with benign thyroid nodules, nine cases with thyroid gland malignancy and 24 healthy control cases in their study in the period of 18 months. Cases that were indicated to undergo FNAC examination and sent by a clinician for biopsy to the radiology unit were included in the study to evaluate the cytopathologic confirmation of the clinic, ultrasonographic, and magnetic resonance imaging (MRI) findings. The quantitative image analysis revealed that the mean apparent diffusion coefficient (ADC) values of thyroid nodules were 2.745.3 ± 0.601mm2/s in the benign group and 0.6952±0.3125 mm2/s in the malignant group.

The normal thyroid tissues had mean ADC values of 1.3441±0.2764 mm2/s. The ADC values of three subgroups were significantly different (P ¼ 0.0001). They concluded that the reduced ADC observed in most types of malignant tumors was due to the consequent reduction of the extracellular extravascular space.

Noda et al., [8] included 36 patients in their study (10 men and 26 women; age range, 14–79 years; (mean age, 57.7±15.2 years) who had solid thyroid nodules recognized by thyroid sonography underwent MRI.

All patients underwent MRI within the 4 weeks before FNAB or thyroidectomy. The quantitative image analysis revealed that the mean ADC value of the benign thyroid nodules (1.88 ±0.5; range, 0.53–2.56) was also remarkably higher (p <0.0001) than that for the papillary carcinomas (0.89 ± 0.1; range, 0.65–1.12).

In our study we considered that the mean ADC values of thyroid nodules were 2.745.3 ± 0.601 mm2/s in the benign group and 0.6952±0.3125 mm2/s in the malignant group according to **Erdem et al.,**[7].

In our study a comparison between the results of the ADC values and cytological examinations for the thyroid nodules was performed. The analysis of data revealed that the benign thyroid nodules exhibited ADC values equal to 2.11±0.719 mm2/s (mean ± standard deviation) while the malignant thyroid nodules exhibited ADC values equal to 0.775±0.0829 mm2/s (mean ± standard deviation). The statistical analysis revealed that the ADC cutoff value between the benign and malignant nodules is equal to 0.85 x10-3mm2/s (p value< 0.05) the sensitivity was 90%, the specificity was 75%, PPV was 90%, NPV was 75% and the accuracy was 85.7%for this cut off value for b value 800 s/mm2.

Our results were in the same line with **Mutlu et al.**[9] who found in their study that the sensitivity, specificity, PPV, NPV and accuracy rates for ADC values in discriminating benign and malignant thyroid nodules were calculated as 80% ,97% ,80% ,97% ,96% respectively for b values 50,400and 1000 s/mm2 when using the cutoff value of 1.0x10-3 mm2/s.

Different studies showed variation in the cutoff values for predicting thyroid carcinoma, so each MRI unit should determine the precise threshold value for predicting malignancy in thyroid nodules as there are variations in MRI systems ,coils and pulse sequences [10].

In our study, there was a case of benign colloid nodule demonstrated ADC value equal to 0.7 mm2/s (considered as false positive results). The conventional MRI appearance of this 3.5 cm nodule was of high T1, low T2 and STIR signal intensity pattern consistent with internal high proteinaceous content that may explain the restricted diffusion within this nodule.

Contrast enhanced MRI provides information concerning the vascularity of lesions. The degree of enhancement represents the degree of vascularity [(11)].

V. Conclusion:

DW-MR imaging has a useful role in the evaluation of the thyroid nodules and post thyroidectomy recurrent nodules providing a good determining tool by the measurement of the ADC value. Contrast enhancement could provide complementary data for differentiation.

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