Clinical Imaging 40 (2016) 913–916

Contents lists available at ScienceDirect

Clinical Imaging

journal homepage: http://www.clinicalimaging.org

Original Article

# The diagnostic value of combination of TI-RADS and ultrasound elastography in the differentiation of benign and malignant thyroid nodules

Jie Xue [a,1], Xiao-li Cao [a,1], Lei Shi [a], Chun-hua Lin [b], Jiahui Wang [c], Lihong Wang [a,*]

[a] Ultrasonic Department, Yantai Yuhuangding Hospital, Yantai, Shandong, 264000, China
[b] Urology Department, Yantai Yuhuangding Hospital, Yantai, Shandong, 264000, China
[c] Central Laboratory, Yantai Yuhuangding Hospital, Yantai, Shandong, 264000, China

ARTICLE INFO

*Article history:*
Received 17 March 2016
Received in revised form 19 April 2016
Accepted 27 April 2016

*Keywords:*
Thyroid imaging reporting and data system, TI-RADS
Elasticity imaging techniques
Thyroid nodule
Ultrasonography

ABSTRACT

**Background:** Here, we evaluated the diagnostic value of combination of thyroid imaging-reporting and data system (TI-RADS) and ultrasound elastography (USE) in risk assessment of thyroid nodules.
**Methods:** The clinical data of 174 patients with 232 nodules were retrospectively analyzed. All nodules were examined by gray-scale ultrasonography and USE and confirmed by histological examination.
**Results:** The sensitivity, specificity, and accuracy of the combination of the two methods were significantly higher than those using a single method.
**Conclusion:** The combination of TI-RADS and USE has high diagnostic sensitivity and accuracy in evaluating the malignant risk of thyroid nodules.



## 1. Background

Ultrasonography is currently the major approach in the diagnosis of thyroid nodules. However the accuracy of ultrasonography is relatively low in differentiating benign and malignant thyroid nodules [1]. Fine needle aspiration (FNA) could be used as a supplement in evaluating the risk of thyroid nodules ≧10 mm. However, despite its high specificity of 60%–98%, the diagnostic sensitivity of FNA could be as low as 65–68% [2]. Many patients underwent operation without a definite qualitative diagnosis, which placed extra physical, psychological, and economic burdens to the patients. To avoid unnecessary biopsy and operation, the thyroid imaging-reporting and data system (TI-RADS) was developed by Parker et al. for risk stratification of thyroid nodules [3]. However, TI-RADS has been limited in clinical application and questioned for its feasibility and practicability due to the practice being too subjective. In recent years, ultrasound elastography (USE) has been increasingly used in the risk assessment of thyroid nodules. A meta-analysis reported 92% overall mean sensitivity and 90% specificity for the diagnosis of malignant thyroid nodules by USE, respectively [4]. In this study, we investigated and discussed the clinical value of the combination of TI-RADS and USE in the differential diagnosis of benign and malignant thyroid nodules.

## 2. Material and methods

### 2.1. Patients

In this retrospective study, 232 nodules in 174 consecutive patients (72 male, 102 female, aged 25–58 years old, median age 43.4) admitted to Yantai Yuhuangding Hospital between September 2011 and December 2013 were examined. The inclusion criteria were patients with solid or cystic-solid mixed nodules that were ≧5 mm, without "egg-shell" calcification on the edge, and surrounding thyroid tissues were normal. For multiple nodules, the large ones or those with malignant probability were chosen. All nodules were examined by gray-scale ultrasonography and USE examinations, and final diagnoses were obtained from pathological evaluation. The maximum diameters of nodules ranged from 7 to 24 mm. This study was approved by the Ethics Committee of Yantai Yuhuangding Hospital. Written informed consents were obtained from patients before all examinations and treatments for the inclusion of clinical data for scientific research and publication purpose.

### 2.2. Imaging techniques

US examinations for all patients were performed by the same physician.

* Corresponding author. Yantai Yuhuangding Hospital, 20 Yuhuangding East Road, Yantai, Shandong, 264000, China. Tel.: +86-535-6691999.
*E-mail address:* wangwangjn168@163.com (L. Wang).
[1] Equal contribution.

http://dx.doi.org/10.1016/j.clinimag.2016.04.014
0899-7071/

Ultrasonography was performed using two ultrasound systems (LogicE9, GE Healthcare, Milwaukee, WI, USA; Aplio™ 500, Toshiba Medical Systems Co. Ltd., Otawara, Japan). Patients took the spine position with adequate exposure of the neck. The thyroid was scanned from the anterior aspect of the neck at different angles (transverse, sagittal, and oblique). Information of the nodules including their location, number, size, shape, boundary, aspect ratio (the ratio of the longitudinal against the axial length), internal echo, ultrasound attenuation and microcalcification as well as any enlargement of cervical lymph nodes were recorded. Extra attention was paid to the lymph nodes at area 3, 4, 6, and 5 (5 A and 5B) of bilateral neck. The characteristics of thyroid nodules were valuated with two-dimensional gray-scale ultrasonography.

For USE examination, the sampling frame of the region of interest (ROI) included the nodules and the surrounding normal thyroid tissue. The probe made slight vibrations upon the nodules at a frequency of twice per second and a depth of pressure of 1–2 mm until it reached the optimal pressure and frequency, which showed all green in the indicator shaft for Logic E9 or regular waveform curves for Aplio 500 scanner. The gray-scale images and elastograms were real-time displayed and monitored simultaneously. The elasticity of diverse tissues was represented by different colors in the elasotogram. Green represented the average tissue hardness within the ROI. Red indicated softer tissues than the average, and blue suggested harder tissues. The color distribution of each nodule was recorded and classified.

### 2.3. Scoring system

Retrospective investigation was done by Medical Picture Archiving and Communication System (Medicon Digital Engineering Co. LTD, Qingdao, China). All ultrasonic images were independently evaluated by two physicians with at least five years of ultrasound work experience. In case of disagreement, the image was evaluated by a third associate chief physician with more than seven years of ultrasound work experience until consensus was reached upon discussion.

The thyroid nodules were scored according to the TI-RADS scoring system [5]:

TI-RADS 1 (Score 1): normal thyroid or diffuse hyperplasia of thyroid.
TI-RADS 2 (Score 2): benign conditions, mainly included the glial Type I, II and III nodules.
TI-RADS 3 (Score 3): probably benign nodules, mostly seen in the Hashimoto's thyroiditis.
TI-RADS 4 A (Score 4): indeterminate nodules (malignancy between 5 and 10%), including solid *iso*-echoic nodules or mix-echoic nodules coated in capsules; hypoechoic nodules with unclear boundaries and no calcification; calcified nodules coated in thick capsules and with rich blood supply.
TI-RADS 4B (Score 5): suspicious nodules (malignancy between 10 and 80%), which are hypochoic, no capsule, with irregular form and boundaries, with perforator blood vessels and with/without calcification.
TI-RADS 5 (Score 6): probably malignant nodules, which are *iso*-echoic or hypochoic, no capsule, with rich blood supply and microcalcification.
Score 1–3 were classified as benign and 4–6 as malignant.

We also scored the nodules using the USE scoring system by Asteria et al. [6] and Rubaltelli et al. [7]:

Score 1: elasticity in the whole examined area (all green).
Score 2: elasticity in a large part of the examined area (majority of the nodule area was green with a little blue area).
Score 3: stiffness in a large part of the examined area (majority of the nodule area was blue with a little green area).
Score 4: a nodule without elasticity (all blue).
Score 1–2 were classified as benign and 3–4 as malignant.

For combined TI-RADS/USE diagnosis, the TI-RADS score and USE score of each nodule were added. A final score of 2–6 were considered benign nodules and 7–10 were malignant nodules. Pathological results were used as a golden standard for evaluating the diagnosis value of TI-RADS/USE combined system in risk assessment of thyroid nodules.

### 2.4. Pathological diagnosis

Tissue samples of each nodule were obtained from operation or ultrasound-guided core biopsy. Surgically resected nodules were subjected to intra-operative frozen section for preliminary risk assessment. Final diagnosis was based on postoperative paraffin section pathological examinations. Nodule tissues obtained from biopsy were fixed in paraformaldehyde and subjected to paraffin section pathological examinations. In case of suspicious malignant samples or atypical samples, immunohistochemical staining was applied to differentiate benign and malignant nodules. If biopsy suggested follicular carcinoma, the whole tumor was surgically removed for definite diagnosis. Benign nodules mainly comprised nodular goiter, glial nodules, adenoma, and Hashimoto's thyroiditis. Malignant nodules were mainly papillary carcinoma, in less case follicular and medullary carcinoma, and occasionally thyroid lymphoma.

### 2.5. Statistics

Statistical analysis was performed using the Statistical Product and Service Solutions 17.0 software. The diagnostic efficacy of USE and TI-RADS were compared by sensitivity, specificity, accuracy, positive predictive value (PPV), and negative predictive value (NPV) using $\chi^2$-test. Receiver operating characteristic curve (ROC) was plotted, and area under the curve (AUC) was calculated. Z-test was utilized to compare the AUC of ROC. $P<.05$ indicated statistically significant difference.

## 3. Results

The diagnosis of the 232 nodules by TI-RADS scoring, USE scoring, combined TI-RADS/USE scoring, and pathological diagnoses was summarized in Table 1. Pathological tests showed that 160 were benign and 72 were malignant (69 papillary carcinomas, 3 follicular carcinomas). Based on the TI-RADS score, 153 nodules were benign (92 nodules scored 2, 61 scored 3), and 79 were malignant (52 scored 4 or 5 points, 27 scored 6). Based on the USE scores, there were 153 benign nodules (53 nodules scored 1, 102 scored 2) and 77 malignant nodules (32 nodules scored 3, 45 scored 4). Based on combined TI-RADS/USE scores, there were 155 benign nodules and 77 malignant nodules (Fig. 1).

Our result showed that both the sensitivity and accuracy of USE evaluation system were significantly higher than the TI-RADS system alone ($\chi^2=3.920$, 7.446. $P<.05$). In case of combined TI-RADS/USE scoring, there was a significant improvement in the sensitivity, specificity, and accuracy of diagnosis than TI-RADS ($\chi^2=7.725$, 6.450, 13.728. $P<.05$) (Table 2).

The ROC of TI-RADS, USE, and combined TI-RADS/USE analysis were individually plotted (Fig. 2), and their AUC were calculated. Result showed that the AUC for TI-RADS diagnosis system was 0.812 with standard error 0.032, 95% confidence interval (CI) = 0.749–0.874. The AUC for USE diagnosis system was 0.833; standard error, 0.034; 95% CI = 0.767–0.899. The AUC for combined TI-RADS/USE diagnosis system

**Table 1**
The number of nodules in each diagnostic group based on the TI-RADS, USE, and combined TI-RADS/USE scoring system

| Pathological classification | TI-RADS | | USE | | TI-RADS/USE | |
|---|---|---|---|---|---|---|
| | Benign | Malignant | Benign | Malignant | Benign | Malignant |
| Benign | 136 | 24 | 147 | 13 | 150 | 10 |
| Malignant | 17 | 55 | 8 | 64 | 5 | 67 |