Correlation between thyroid image reporting and data system and fine-needle aspiration cytology in the assessment of suspicious thyroid nodules

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Objectives
We are trying to evaluate both ultrasound criteria [based on thyroid image reporting and data system (TI-RADS) classification] and fine-needle aspiration cytology (FNAC) in the assessment of suspicious thyroid nodules by analyzing their results with the final histopathology outcome after thyroidectomy to detect their sensitivity and specificity in the differentiation of benign and malignant thyroid nodules.

Patients and methods
This is a prospective comparative study conducted in Ain Shams University Hospitals in Egypt from December 2018 to December 2020. The study included 50 patients suffering from suspicious thyroid nodules, either single or multiple nodules. Patients underwent ultrasound based on TI-RADS system and FNAC, then all patients underwent either total or hemithyroidectomy operation. Specimens were sent for histopathological examination, which is considered as gold standard. The results of TI-RADS and FNAC (based on Bethesda categories) were compared with the final histopathology outcome.

Results
The accuracy, sensitivity, specificity, positive predictive, and negative predictive value of FNAC were 80, 77.8, 98, 90, and 88.2% and TI-RADS values were 75, 88, 92, 81, and 76.6%, respectively. FNAC was less sensitive but more specific than TI-RADS. Our study found that the overall compatibility between TI-RADS and FNAC is 67% in the diagnosis of suspicious thyroid nodules (82.6% in benign cases, 68.4% in indeterminate cases, 50% in malignant cases).

Conclusion
TI-RADS is more sensitive in diagnosing suspicious thyroid nodules but FNAC is more specific, FNAC is a minimally invasive method that can be used to distinguish malignant from benign lesions with a high degree of accuracy (80%), and both TI-RADS and FNAC systems are effective diagnostic modalities for predicting malignant lesions in patients having suspicious thyroid nodules.

Keywords:
fine-needle aspiration cytology, histopathology, suspicious thyroid nodules, thyroid image reporting and data system

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Introduction

Thyroid nodules are very common, with an estimated prevalence of ~4% by palpation (5% in women and 1% in men living in iodine-sufficient regions). Clinically apparent thyroid nodules were present in 6.4% of the women and 1.6% of the men, with an estimated annual incidence, by palpation, of 0.001. The lifetime risk of developing a thyroid nodule is reported to be 15%. Nevertheless, only 5% of the clinically apparent thyroid nodules are malignant [1]. Thyroid carcinoma annual incidence is 1–2 per 100 000 population, which accounts for 90% of the malignancies of the entire endocrine system, 1% of the total human malignancies, and 0.5% of total deaths from malignancies. Although thyroid-malignant tumors are not usually aggressive, thyroid malignancies are responsible for more deaths than all other malignancies of the endocrine system [2].

Thyroid nodules can be benign (Hashimoto's thyroiditis, subacute thyroiditis, colloid nodule, simple cyst, hemorrhagic cyst, and follicular adenoma) or malignant [papillary, follicular, medullary, anaplastic, Hurthle cell (oncocytic) carcinomas, thyroid lymphoma, and metastases] [3].

Evaluation of a patient with a thyroid nodule should be initially started with a detailed history, clinical examination, laboratory investigations, and imaging studies [4]. Ultrasound (US) is a noninvasive radiological technique that should be done in all patients with a thyroid disease to differentiate malignant from benign nodules. Having a single nodule, irregular edges, and microcalcification increase the chance of malignancy 3.6, 5.4, and 39 times, respectively [5]. Thyroid image reporting and data system (TI-RADS) is a risk-stratification system for classifying thyroid lesions and was recently recognized in an American College of Radiology (ACR) white paper. Its use is being advocated similar to BI-RADS category for breast lesions. In 2017, a white paper was released by the ACR Committee on thyroid imaging with a standardized scoring system, with guidance on fine-needle aspiration (FNA) and follow-up. ACR TI-RADS is a reporting system for thyroid nodules on US proposed by the ACR. This uses a standardized scoring system for reports providing users with recommendations for when to use FNA or US follow-up of suspicious nodules, and when to safely leave alone nodules that are benign/not suspicious [6].

Fine-needle aspiration cytology (FNAC) biopsy is recommended for suspicious lesions (TR3–TR5). If there are multiple nodules, the one with the highest ACR TI-RADS grades should be sampled (rather than the largest). TR1 and TR2: no FNA required, TR3: more than or equal to 1.5-cm follow-up, more than or equal to 2.5-cm FNA, TR4: more than or equal to 1.0-cm follow-up, more than or equal to 1.5-cm FNA, and TR5: more than or equal to 0.5-cm follow-up, more than or equal to 1.0-cm FNA [7]. According to the American Association of Clinical Endocrinologists guidelines, FNAC biopsy is the most effective and accessible method for differentiating between malignant and benign thyroid lesions, with an accuracy around 95% [8].

Aim

In this study, we are trying to evaluate and compare the accuracy of both TI-RADS and FNAC in the assessment of suspicious thyroid nodules by matching their results with the final histopathological outcomes.

Patients and methods

This is a prospective comparative study conducted in Endocrine Surgery, Radiology and Pathology Departments, Ain Shams University Hospitals, in Egypt from December 2018 to December 2020. The study includes 50 patients with suspicious thyroid nodule/nodules. After approval of the study protocol by the Ethical Committee and obtaining fully informed written patients' consent for the participation in the study.

Preoperative assessment: patients were evaluated in the OPD through clinical, laboratory, and radiological tools.

History taking: full clinical history, personal history, present history, and past history, especially history of any metabolic or hepatic disorder recorded.

Examination: then patients examined generally as regards vital signs, body examination plus local neck examination.

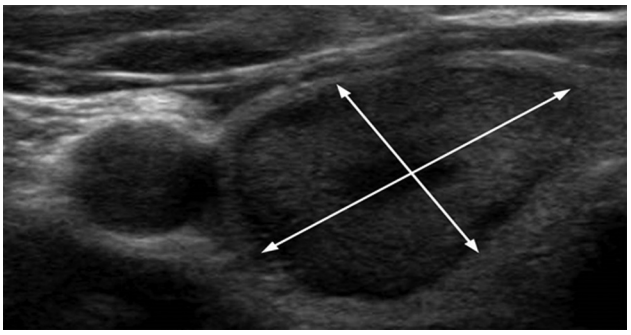
Investigations: laboratory exams are done, including routine preoperative investigations and serum-free triiodothyronine, free tetraiodothyronine, thyroid-stimulating hormone, and serum calcitonin. Diagnostic imaging was done, including radionuclide thyroid scan and high-resolution thyroid US according to TI-RADS classification as follows: TI-RADS 1: benign (no FNA), TI-RADS 2: not suspicious (no FNA), TI-RADS 3: mildly suspicious (FNA if $\geq$2.5 cm and follow-up if $\geq$1.5 cm), TI-RADS 4: moderately suspicious (FNA if $\geq$1.5 cm and follow-up if $\geq$1 cm), and TI-RADS 5: highly suspicious (FNA if $\geq$1 cm and follow-up if $\geq$0.5 cm). Then USG-guided FNAC was done from thyroid nodules if indicated [6]. FNAC was analyzed according to Bethesda System divided into six categories: Bethesda 1 (nondiagnostic), Bethesda 2 (benign), Bethesda 3 (AUS/FLUS), Bethesda 4 (follicular neoplasm), Bethesda 5 (suspicious for malignancy), and Bethesda 6 (malignant) [9]. Before surgery, patients were admitted to Endocrine Surgery Department and prepared for surgery, then written informed consent was taken from all participants before operation.

Inclusion criteria were patients who are fit for surgery, adult male or female patients, age (>18 years), and patients who have suspicious single or multiple nodules, TR3, TR4, and TR5 by US criteria (TI-RADS classification).

Exclusion criteria were patients with TR1 and TR2, age more than 60 years, and patient refusal.

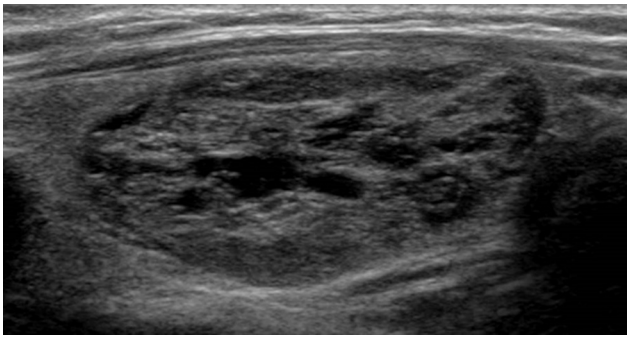
High-resolution thyroid US and US-guided FNAC biopsy: the sonographic features were examined, such

Figure 1



Sagittal (a) and transverse (b) sonograms of an obliquely oriented hypoechoic nodule demonstrating measurement technique [6].

Figure 2



Solid right-lobe nodule that contains a few cystic spaces, not warranting classification as spongiform [6].

as the internal composition, echogenicity, margins, presence of calcifications, and the shape of the nodule, also the internal structure of the nodule demarcated as cystic, solid, or mixed. For a patient with more than one thyroid nodule, the nodule with the most suspicious sonographic features was recorded as the nodule of interest for FNAC. If the nodule shows these features: irregular border, microcalcifications, hypoechogenicity, and central flow by Doppler study will be considered suspicious for malignancy (Figs 1 and 2). Then under US guidance, a special needle entered through the skin at an oblique angle and moved through the center of the nodule of interest gently with a mild suction. Then the specimen was interpreted by the pathologist and categorized into six categories according to the Bethesda system.

Surgery:

(1) Preparation: either total or hemithyroidectomy was done for all patients included in our study. Both US and computed tomography neck were done for patients with significant goiters, to rule out any retrosternal extension and also if goiter was suspicious for malignancy. All patients underwent vocal cord assessment before surgery.
(2) Anesthesia: general anesthesia, endotracheal intubation.
(3) Positioning: the patient is positioned supine with the neck extended. Rolled towels are placed under the shoulders, which allow sufficient neck extension. A sponge doughnut is placed under the occiput for adequate head support.
(4) Procedure: a collar incision about 2 cm above the sternal notch. A subplatysmal flap elevated superiorly and inferiorly. The midline of cervical fascia was dissected superiorly and inferiorly with separation of strap muscles at midline once the thyroid gland is recognized, ligation of the middle thyroid vein, capsular blunt dissection at the lateral aspect of the thyroid lobe, and the superior pedicle identified and then divided using either ties or harmonic scalpel. Blunt dissection or a harmonic scalpel was used to cut Berry's ligament and all other fascial attachments. The parathyroid glands were identified and protected, as well as the recurrent laryngeal nerves. After removal of the dissected thyroid gland/lobe, hemostasis was done and a suction drain was kept for one day. Then, the wound was closed in layers and thyroid specimens were sent to the laboratory for histopathological evaluation (Fig. 3).

Figure 3

Thyroid specimen after total thyroidectomy for a case presented with multiple thyroid nodules with dominant left suspicious nodule (TI-RADS 5). TI-RADS, thyroid image reporting and data system.

Statistical analysis

Data were presented as mean±SD, ranges, numbers, and ratios. The results were analyzed using Wilcoxon's ranked test for unrelated data (Z test) and χ^2 test for numerical data. Statistical analysis was conducted using the SPSS (version 19 for Windows; SPSS Inc.,

Chicago, Illinois, USA) statistical package. The *P* value less than 0.05 was considered as statistically significant.

Results

In this study, 110 participants of thyroid nodules were recruited of which 50 participants fulfilled our inclusion criteria. The basic demographic profile of our participants shows that the mean age is 39.10±10.85, range: 22–60 years, our study population had a female predominance with 35 (70.0% of patients) female patients and 15 (30.0% of patients) male patients (Table 1). Nodules were in the right lobe of the thyroid gland in 15 patients, in the left lobe in 11 patients, in the isthmus in two patients, and in both lobes in 22 patients, 29 patients had multiple nodules and 21 patients had a single nodule, as regards nodule size, the highest malignancy risk was observed in nodules less than 2 cm (71.4% for nodules <1 cm and 73.3% for nodules 1–1.9 cm) with no increase in malignancy risk for nodules more than 2 cm (61.9%) (Table 2). About 38 patients underwent total thyroidectomy, while hemithyroidectomy was done for only 12 patients. The mean operative time in our study 66.30±20.80, range: 45–150 min. Also the median hospital stay (interquartile range) was 1 (1–1), range: 1–5 days. In our study, postoperative complications were minor with three patients who had transient hoarseness of voice, two patients had temporary hypocalcemia, and one patient had wound seroma (Table 3).

Twenty-three patients with thyroid nodules in our study were TI-RADS 3 (probably benign), and FNAC confirmed this result in 19 out of 23 patients revealing a 82.6% similarity rate between US and FNAC. From the 19 cases that were categorized as TI-RADS 4 (indeterminate), five out of 19 patients were benign on FNAC (Bethesda II), only one out of 19 cases had a FNAC biopsy established as cancer, while the remaining 13/19 patients fell in Bethesda III, IV, and V, giving a 68.4% similarity rate between the US and FNAC. From the eight cases that were categorized as TI-RADS 5 (malignant), one out of eight patients were benign on FNAC biopsy (false-positive impression of the US), three out of eight patients were suspicious on FNAC (Bethesda IV), and only four out of eight patients had a FNAC biopsy established as cancer, giving a 50% similarity between the US and FNAC. From the previous results, we can find that the overall similarity rate between TI-RADS and FNAC is 67% (Tables 4 and 5).

Table 1 Patients' demographic data

Data	Features	*N*=50
Age	Mean±SD	39.10±10.85
	Range	22–60
Sex	Female	35 (70.0)
	Male	15 (30.0)

Data are presented as mean±SD and numbers, ranges, and percentages are in parenthesis.

Table 2 Thyroid nodule pattern

Data	Features	*n* (%)		
Number of nodules	Single	21 (42.0)		
	Multiple	29 (58.0)		
Site of nodules	Right	15 (30.0)		
	Left	11 (22.0)		
	Bilateral	22 (44.0)		
	Isthmus	2 (4.0)		
Size of nodules		Total number	Malignant number	
	<1 cm	14	10	71.4%
	1–1.9 cm	15	11	73.3%
	>2 cm	21	13	61.9%

Table 3 Operative and postoperative collected data

Data	Features	*n* (%)	
Type of (thyroidectomy) operation	Hem-thyroidectomy	12 (24.0)	
	Total thyroidectomy	38 (76.0)	
Hospital stay (days)	Median (IQR)	1 (1–1)	Range (1–5)
Operative time (mins)		66.30 ±20.80	Range (45–150)
Postoperative complications	Transient hoarseness of voice	3 (6.0)	
	Transient hypocalcemia	2 (4.0)	
	Wound seroma	1 (2.0)	
	Noncomplicated	44 (88.0)	

Data are presented as mean±SD and numbers; ranges and percentages are in parenthesis. IQR, interquartile range.

Table 4 Thyroid ultrasound result based on thyroid image reporting and data system and comparison with the final postoperative histopathology results

US	Histopathology [*n* (%)]		Total number
	Benign	Malignant	
TI-RADS			
TR3	20 (87.0)	3 (13.0)	23
TR4	16 (84.2)	3 (15.8)	19
TR5	2 (25.0)	6 (75.0)	8
Total	38 (76.0)	12 (24.0)	50

TI-RADS: thyroid image reporting and data system.

Table 5 Fine-needle aspiration cytology results based on the Bethesda system and comparison with the final postoperative histopathology results

FNAC	Histopathology [*n* (%)]		Total number
	Benign	Malignant)	
Bethesda system			
II	24 (96.0)	1 (4.0)	25
III	6 (75.0)	2 (25.0)	8
IV	4 (44.4)	5 (55.6)	9
V	1 (33.3)	2 (66.7)	3
VI	1 (20.0)	4 (80.0)	5
Total	36 (72.0)	14 (28.0)	50

FNAC, fine-needle aspiration cytology.

Table 6 Analysis of thyroid image reporting and data system and fine-needle aspiration cytology results by correlation with the final postoperative histopathology results

Parameters	Accuracy	Sensitivity	Specificity	PPV	NPV
TI-RADS	75	88	92	81	76.6
FNAC	80	77.8	98	90	88.2

FNAC, fine-needle aspiration cytology; NPV, negative predictive value; PPV, positive predictive value; TI-RADS, thyroid image reporting and data system. Sensitivity=TP, specificity=TN, PPV=TP/total positive (TP+FP), NPV=TN/total negative (TN+FN), and accuracy=(TP+TN)/total number of patients.

By comparing with the final pathological results, the overall accuracy of TI-RADS for predicting malignancy was 75% with a sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of 88, 92, 81, and 76.6% respectively, the overall accuracy of FNAC for predicting malignancy was 80% with a sensitivity, specificity, PPV, and NPV of 77.8, 98, 90, and 88.2%, respectively (Table 6).

Discussion

Detailed history, clinical examination, laboratory exams involving thyroid-function tests, thyroid US based on TI-RADS features, and US-guided FNAC are the key for proper evaluation of thyroid nodules.

The accessibility of TI-RADS and recent validation of this US classification system by the ACR permits a precise clinical and pathological correlation. In many countries around the world, surgeons, radiologists, and endocrinologists become aware of using the US classification system (TI-RADS) for evaluation of thyroid lesions and use it regularly in their clinical performance [10].

After analysis of 50 cases of thyroid nodules in our study, we have reached that the overall accuracies of both TI-RADS and FNAC were 75 and 80%, respectively.

De *et al.* [11] conducted an observational study on 137 consecutive patients of solitary euthyroid nodule during 2020. All participants underwent USG according to TI-RADS and FNAC where applicable. Surgical biopsy report was used as a gold standard. FNAC classification was equally sensitive and more specific than TI-RADS.

If we compare our results with the outcomes of De and colleagues study, the overall accuracy of US in our study was 75% compared with 61% in the previous study. The US had a higher sensitivity in predicting malignancy in our study, 88 versus 80% and higher specificity 92 versus 47.2%, also PPV and NPV were 81 and 76.6 in our study compared with 51.3 and 77.3 in the previous study. The overall accuracy of FNAC in our study was 80% compared with 85% in the previous study. The FNAC had a lower sensitivity in predicting malignancy in our study, 77.8 versus 80% and higher specificity 98 versus 90%, also PPV and NPV were 90 and 88.2 in our study compared with 86 and 86.6 in the previous study.

In Singaporewalla *et al.* [12] study, a retrospective analysis of 100 consecutive cases over 1 year (January–December 2015), 74 were considered benign or probably benign, 20 were suspicious for malignancy, and six were indeterminate on US. The 20 patients were classified as TI-RADS 5, only 12 were confirmed as malignant with FNAC biopsy, and the remaining eight were benign. This gives them a 60% accuracy of US in predicting malignancy. Similarly, in our study, we found that among the eight cases that were categorized as TI-RADS 5, six out of eight cases had a FNAC biopsy established as cancer (75% accuracy).

If we compare our results with the outcomes of Singaporewalla and colleagues, study, we had an overall accuracy of 75% compared with 83% in the previous study. The US had a higher sensitivity in predicting malignancy in our study, 88 versus 70.6%, but almost the same specificity 92 versus 90.4%, also, we had lower NPV that was 76.6 compared with 93.8 in the previous study.

In Horvath *et al.* [13] study, the TI-RADS classification was evaluated at the third stage of this study in a sample of 1097 nodules (benign: 703, follicular lesions: 238;,and carcinoma: 156), on comparing our results with the data reported by Horvath and colleagues, our US had the same sensitivity in predicting malignancy in thyroid nodules, 88% compared with 88%, but higher specificity 92% compared with 49%. We also had a lower NPV of TI-RADS score predicting malignancy as well, 76.6% compared with 88%.

Several studies have verified the high global accuracy of FNAC biopsy for assessment of thyroid nodules, and this result has been established, mainly for patients with a solitary thyroid nodule and those with some US criteria of malignancy; however, FNAC biopsy has displayed less accuracy in the assessment of multinodular goiter [14].

The limitation of FNAC includes false-negative results and false-positive results. A comparative study was done by Bloch [15] between FNAC and histopathology and found that the accuracy of FNAC was 91.6%. Garg *et al.* [16] have a similar study in which FNAC revealed a sensitivity of 97%, specificity 100%, a PPV of 96%, and a NPV of 100%. Mundasad *et al.* [17] had done a similar study and identified that FNAC had a sensitivity 52.6%, specificity 86.6%, and accuracy 79.1% for thyroid malignancy. Krzysztof *et al.* [18] reported in their study in 2016 that the rate of prediction of thyroid cancer by FNAC was three times higher in the patients with a solitary thyroid nodule compared with those with multiple thyroid nodules and it was statistically significant, 98 versus 96%, respectively.

In our study, the overall accuracy of FNAC biopsy in comparison with the final postoperative pathological reports in our study was 80% with sensitivity and specificity of 77.8 and 98%, respectively.

The limitations of this study are a detection bias introduced to those US examinations, the US examiner was not blinded to the patient's medical history, laboratory results (such as elevated serum thyroglobulin levels), and previous imaging study results. Finally, the real value of true negative results may be falsely low.

Conclusion

We can conclude that TI-RADS is highly sensitive but FNAC is a more specific and accurate test in identifying suspicious thyroid nodules. There is a good concordance between US report using TIRAD criteria and FNA using Bethesda to evaluate suspicious thyroid nodules. For accurate diagnosis and institution of more preserving surgery, a combination of TI-RADS and BETHESDA is needed simultaneously. Both systems are complementary to each other. Also, TI-RADS has allowed us to improve patient management and cost-effectiveness, avoiding unnecessary FNAC.

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Conflicts of interest

There are no conflicts of interest.

References

1 Vander JB, Gaston EA, Dawber TR. The significance of nontoxic thyroid nodules. Final report of a 15-year study of the incidence of thyroid malignancy. Ann Intern Med 2012; 69:537–540.

2 Landis SH, Murray T, Bolden S, Wingo PA. Cancer statistics. CA Cancer J Clin 2008; 48:6–29.

3 Gharib H, Papini E. Thyroid nodules: clinical importance, assessment, and treatment. Endocrinol Metab Clin North Am 2007; 36:707–735.

4 Grant E, Tessler F, Hoang J, Langer J, Beland M, Jetal C, *et al.* Thyroid ultrasound reporting l exicon: white paper of the ACR thyroid imaging, reporting and data system (TIRADS) committee. J Am Coll Radiol 2015; 12 (12PtA):1272–1279.

5 Ugurlu S, Caglar E, Yesim TE, Tanrikulu E, Can G, Kadioglu P. Evaluation of thyroid nodules in Turkish population. Intern Med 2008; 47:205–209.

6 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.

7 Hoang JK, Langer JE, Middleton WD, Wu CC, Hammers LW, Cronan JJ, *et al.* Managing incidental thyroid nodules detected on imaging: white paper of the ACR Incidental Thyroid Findings Committee. J Am Coll Radiol 2017; 12:143–150.

8 Naykky S, Juan P, Spyridoula M, Ana E, Rene R, Michael R, *et al.* Diagnostic accuracy of ultrasound-guided fine needle aspiration biopsy for thyroid malignancy: systematic review and meta-analysis. Endocrine 2016; 53:651–661.

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

10 Hossein G, Enrico P, Jeffrey R, Daniel S, Mack H, Laszlo H, *et al.* American Association of Clinical Endocrinologists, American College of Endocrinology, and AssociazioneMediciEndocrinologiMedical Guidelines for Clinical Practice for the Diagnosis and Management of Thyroid Nodules-2016 Update. Endocr Pract 2016; 22:622–639.

11 De D, Dutta S, Tarafdar S, Kar SS, Das U, Basu K, *et al.* Comparision between sonographic features and fine needle aspiration cytology with histopathology in the diagnosis of solitary thyroid nodule. Indian J Endocrinol Metab 2020; 24:349–354.

12 Singaporewalla R, Hwee J, Lang T, Desai V. Clinicopathological correlation of thyroid nodule ultrasound and cytology using the TIRADS and Bethesda Classifications. World J Surg 2017; 41:1807–1811.

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

14 Baloch Z, LiVolsi V, Asa S. Diagnostic terminology and morphologic criteria for cytologic diagnosis of thyroid lesions: a synopsis of the National Cancer Institute Thyroid Fine-Needle Aspiration State of the Science Conference. Diagn Cytopathol 2008; 36:425–437.

15 Bloch M. Fine needle aspiration biopsy of head & neck masses. Otolaryngol Head Neck Surg 1997; 89:62–68.

16 Garg S, Mohan H, Nagarkar N, Handa U. Role of fine needle aspiration cytology in diagnosis and –management of thyroid lesions: a study on 434 patients. J Cytol 2008; 25:13.

17 Hirachand S, Maharjan M, Lakhey M, Thapa R, Kafle S. Accuracy of fine needle aspiration cytology in diagnosis of thyroid swelling. J Pathol Nepal 2013; 3:433–436.

18 Krzysztof K, Dorota D, Beata W, Marta S, Paweł D, Krzysztof S, *et al.* Fine-needle aspiration biopsy as a preoperative procedure in patients with malignancy in solitary and multiple thyroid nodules. PLoS ONE 2016; 11:1.