Journal of Endocrinological Investigation
https://doi.org/10.1007/s40618-018-0935-8

ORIGINAL ARTICLE

Thyroid ultrasonography reporting: consensus of Italian Thyroid Association (AIT), Italian Society of Endocrinology (SIE), Italian Society of Ultrasonography in Medicine and Biology (SIUMB) and Ultrasound Chapter of Italian Society of Medical Radiology (SIRM)

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Received: 5 June 2018 / Accepted: 3 August 2018

Abstract

Thyroid ultrasonography (US) is the gold standard for thyroid imaging and its widespread use is due to an optimal spatial resolution for superficial anatomic structures, a low cost and the lack of health risks. Thyroid US is a pivotal tool for the diagnosis and follow-up of autoimmune thyroid diseases, for assessing nodule size and echostructure and defining the risk of malignancy in thyroid nodules. The main limitation of US is the poor reproducibility, due to the variable experience of the operators and the different performance and settings of the equipments. Aim of this consensus statement is to standardize the report of thyroid US through the definition of common minimum requirements and a correct terminology. US patterns of autoimmune thyroid diseases are defined. US signs of malignancy in thyroid nodules are classified and scored in each nodule. We also propose a simplified nodule risk stratification, based on the predictive value of each US sign, classified and scored according to the strength of association with malignancy, but also to the estimated reproducibility among different operators.

Keywords Thyroid · Thyroid nodules · Thyroid ultrasonography · Autoimmune thyroiditis · Graves' disease · Thyroid cancer

Introduction

Thyroid ultrasonography (US) is the gold standard for thyroid imaging and its widespread use is due to an optimal spatial resolution for superficial anatomic structures, a low cost and the lack of health risks. Thyroid US is currently used for the diagnosis and follow-up of diffuse or focal thyroid illnesses such as Hashimoto's thyroiditis [1, 2], Graves' disease [3, 4], goiter and thyroid nodules [5–9].

Thyroid hypoechogenicity has been shown to be indicative of thyroid autoimmunity, due to a diffuse lymphocytic infiltration that disrupts the normal array of thyroid

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parenchyma in Hashimoto's thyroiditis or to the microfollicular pattern and increased vascularity in Graves' disease [3–10]. Thyroid hypoechogenicity at ultrasound helps to identify patients who have a diffuse Hashimoto's thyroiditis among a larger group of patients with goiter and circulating thyroid autoantibodies [3]. The pattern of thyroid hypoechogenicity at ultrasound was shown to have a higher sensitivity than thyroid autoantibody positivity for diagnosing or predicting hypothyroidism and hyperthyroidism [11, 12].

In nodular thyroid disease, conventional US provides information regarding the size of nodules and defines patterns correlated with the risk of cancer. Several studies have been conducted to establish the usefulness of thyroid US in the diagnosis of benign versus malignant thyroid nodules [5–8, 13–15]. The US features more frequently associated with thyroid carcinoma are hypoechogenicity, absence of a halo sign, the presence of microcalcifications, a "taller than wide" shape [13–18]. However, the sensitivity, specificity, and accuracy of these US signs are extremely variable in the literature. It is widely recognized that any single ultrasound pattern cannot be considered specific for malignancy. Rago et al. demonstrated that one single parameter is weakly predictive of malignancy, while the combination of US features has a higher specificity than any single pattern, but this gain of specificity is achieved at the expense of a lower sensitivity [13]. Most scientific societies agree that US feature should support the indication to perform fine needle aspiration (FNA). To this purpose, several classification systems have been proposed with the aim to stratify the risk of cancer in thyroid nodules [7, 19–25]. Some of these systems were termed TI-RADS (Thyroid Imaging, Reporting and Data System) because they were modeled according to the American Committee of Radiology BI-RADS, which has been widely accepted in breast imaging. Some societies, such as the American Thyroid Association (ATA), have taken a slightly different, pattern-oriented approach [6]. The plethora, complexity, and lack of congruence of these systems have limited their adoption in the clinical practice. Furthermore, the comparison of the scoring systems currently proposed has shown relevant differences in the stratification of risk [26, 27].

Aside the well-recognized advantage, thyroid US has also drawbacks such as the poor reproducibility, due to differences in the equipments used, and a lack of a standardized US reporting. To fully capitalize the diagnostic capabilities of an ultrasound examination in the context of thyroid disease, the purpose of this consensus statement is to standardize the report of thyroid US through the definition of common minimum requirements and a correct terminology.

Thyroid US methodology

Thyroid US is performed with the patient lying in the supine position and having his/her neck extended. A high-frequency (7.5–14 MHz) linear transducer, along with color flow or power Doppler examination, is used. Limitations exist for large thyroid glands, such as multinodular sub-sternal goiters, and for the upper mediastinum exploration, which may benefit from additional scans using a 6-MHz linear transducer or a 3–5-MHz convex transducer. Elastosonography, a tool nowadays available in a growing fraction of modern US equipments, may add useful information in the evaluation of thyroid nodules (Fig. 2).

(a) Perform a thorough transverse US scanning from the sub-lingual position to the subclavicular region, starting with a global assessment of the thyroid gland and obtaining an anatomical overview of its relation with the central neck structures.
(b) Using transverse and longitudinal US scanning, focus on the location, size, shape, margins and echostructure of the right and left lobe and isthmus. Detect the presence of focal lesions, their precise location, size, morphology, vascularization and elasticity by elastosonography, if available.
(c) Using transverse US scanning, perform a global assessment of the central and cervical lymph nodes. Start from the sub-mental group (level Ia) to the central compartment (level VI) until the subclavicular region. Then move to the sub-mandibular group (level Ib) and, maintaining as anatomical reference the jugular carotid short axis, explore II–III–IV levels (respectively, upper–medium–lower jugular groups). Thereafter, scan transversely from the sternocleidomastoid muscle to the supraclavicular region to explore the V level (posterior triangle group), on both sides. Focus on clinically relevant lymph nodes obtaining transverse and longitudinal scanning parallel to the long axis to evaluate size, morphology and vascularization.
(d) Evaluate any accessory pathological findings in the thyroid nearby space (e.g. parathyroid glands, salivary glands, vessels).

Rules for US reporting

(a) Images should be labeled stating the patient's name and facility identification, the examination date, the anatomic site and side.
(b) Describe thyroid position and shape when abnormal. Report the size of the thyroid gland (through estimation of the thyroid volume or the maximum diameter

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of depth, width and length, the parenchymal echostructure, echogenicity and vascularization (Table 1).

(c) Focus on the presence of focal lesions within the thyroid, which should be defined as thyroid nodules or pseudo-nodules and report their precise location, morphology and vascularization (Table 2). Report the precise location of thyroid nodules when more than one is detected. It will allow avoiding mistakes in guiding fine needle aspiration (FNA) and will guarantee inter-observer agreement in the US follow-up. In multinodular goiter report dominant and/or suspicious nodule(s). Describe them following a predetermined order, e.g. from the top to the bottom of the right lobe, the left lobe and then the isthmus (the thyroid nodules can be numbered to help their identification). Optionally, add a schematic representation of thyroid lesions along with the US report. Most importantly, add for each thyroid nodule an estimation of the US risk of malignancy (see below).

(d) Report position, size and features of clinically relevant lymph nodes (Table 3), pointing out the suspicious one(s).

(e) Report accessory pathological findings in the thyroid nearby space (e.g. hyperplastic/adenomatous, parathyroid glands, abnormal salivary glands, vessels).

US report in autoimmune thyroid diseases (ATD) (Figs. 1, 2, 3, 4, 5)

The echographic pattern of ATD is due to the pathological changes typical of these conditions. Hashimoto's thyroiditis is characterized by lymphocytic infiltration of the gland with lymphoid follicles replacing thyroid follicles and reducing the follicular cell/colloid interface, the main factor of the peculiar echogenicity of a normal thyroid parenchyma [1, 2]. The degree of lymphocytic infiltration and fibrosis is the main determinant of the different echogenic patterns observed in Hashimoto's patients. Graves' disease is characterized by hypercellularity, scanty colloid and hypervascularization resulting in a similar hypoechoic pattern [3, 4]. The hypoechoic pattern is a useful sign both for diagnosis in patients with Hashimoto's thyroiditis and negative serum thyroid autoantibodies and

Table 1 US report of the thyroid gland

1. Position	Normal location Mediastinal extension
2. Shape	Normal shape Presence of lobe asymmetry Presence of thyroid anatomic variants (lobe agenesis, ectopic thyroid, pyramidal lobe, thyroglossal duct nodule or cyst, Zuckerkandl's tubercle)
3. Size	Report the three diameters for each lobe in mm[a] Report thyroid volume in ml[b]
4. Echotexture (echoes distribution)	Homogeneous: uniform appearance of the thyroid parenchyma Heterogeneous: non-uniform appearance of the parenchyma, due to an irregular echo pattern showing numerous micro-nodules or echogenic septa
5. Echogenicity (echoes brightness)	Normal echogenicity: higher echogenicity compared to pre-thyroid (neck strap) muscles, similar/slightly higher echogenicity compared to salivary glands [1, 2] Hypoechogenicity: diffusely reduced echogenicity of thyroid parenchyma Mild: thyroid parenchyma slightly darker than normal Moderate: thyroid parenchyma clearly darker, but less dark than neck strap muscles Marked: thyroid parenchyma clearly darker, similar or higher than neck strap muscles
6. Vascular pattern (color and power Doppler)	Pattern 0 (reduced): parenchymal flow is absent or limited to few sub-capsular vessels Pattern 1 (normal): prevalent blood flow in main peripheral thyroid arteries and sub-capsular vessels, with scarce parenchymal blood flow with patchy, uneven distribution Pattern 2 (moderately increased): clearly increased parenchymal blood flow with patchy distribution Pattern 3 ("thyroid inferno"): markedly increased blood flow with diffuse homogeneous distribution [9]

[a]A standardized order of the diameters should be used: antero-posterior (AP), transverse (T), longitudinal (L) diameter. This will likely avoid ambiguity, as well as ensure that subsequent measurements of the same structure are recorded in a similar fashion, even though in different settings

[b]Thyroid volume is estimated summing the volume of each lobe calculated by the ellipsoid formula (AP × T × L × 0.52). Report isthmus size if AP diameter is > 0.5 cm. The normal thyroid volume varies with age, sex and geographic area. In Italy (borderline iodine sufficient area) the mean estimated thyroid volume was 12.9 ± 3.6 and 9.2 ± 2.9 ml in males and females, respectively [10]. Goiter is defined when thyroid volume is greater than the mean + 2 SD in each sex [males: > 20.1 (12.9 ± 7.2) ml; females: > 15 (9.2 ± 5.8) ml]

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Table 2 US report in nodular thyroid disease

1. Position	Superior/medium/inferior, anterior/posterior, paraisthmic/isthmic, define if close to the thyroid capsule (sub-capsular)
2. Size	Report the three diameters for each nodule (depth or AP, width or T, length or L)
3. Shape	Round: equal length of the three diameters Oval: depth less than width and depth less than length Irregular: neither oval nor round, including 'taller than wide' (depth > width) and 'taller than long' (depth > length) shape
4. Composition	Solid: composed almost entirely of solid tissue with < 10% liquid Mixed predominantly solid: liquid component > 10% but < 50% Mixed predominantly cystic: liquid component > 50% but < 90% Cystic: composed entirely or nearly entirely of liquid (> 90%) Spongiform appearance: tiny cystic spaces separated by thin septa
5. Echotexture	Homogeneous: uniform appearance of parenchyma Heterogeneous: non-uniform appearance of parenchyma
6. Echogenicity of solid nodule	Isoechoic: brightness similar to the surrounding thyroid parenchyma. When the echogenicity of the surrounding thyroid tissue is decreased, such as in Hashimoto's thyroiditis, the echogenicity can be compared to that of the sub-mandibular salivary glands Hyperechoic: brighter appearance in comparison with the surrounding thyroid parenchyma Mildly hypoechoic: darker appearance in comparison with the surrounding thyroid parenchyma, but less dark than neck strap muscles Markedly hypoechoic: dark appearance, similar or higher than that of the neck strap muscles
7. Margins	Smooth margins: clear demarcation with respect to the surrounding thyroid parenchyma Ill-defined margins: lack of clear demarcation with respect to the surrounding thyroid parenchyma. Ill-defined margins are distinct from irregular margins and do not alter the nodule risk category Irregular margins: presence of one or more sharp angles of the margins (spiculated) or presence of one or more smooth focal round protrusions of the margins (lobulated) Halo/rim: describe as thin or thick, partial or complete
8. Calcifications	Macrocalcification: > 1 mm coarse calcifications with posterior acoustic shadowing Egg shell calcifications: echogenic line surrounding the nodule giving an appearance of discrete calcified wall, along with marked posterior acoustic shadowing Microcalcifications: < 1 mm most often round calcifications, without acoustic shadowing
9. Accessory features	Comet tail: reverberation artifacts within cystic component Extracapsular invasion: interruption of thyroid capsule
10. Elastosonography	Score 1: nodules with high elasticity Score 2: nodules with inhomogeneous distribution Score 3: nodules with high stiffness Report strain ratio or Kpa-M/s (if shear wave available) > cut-off values, depending on the equipment used and more recent literature [30–35]
11. Vascularity	Type I: absence of intranodular or perinodular flow Type II: presence of perinodular and/or slight intranodular flow Type III: presence of marked intranodular flow [36]

Table 3 US report in lymph-nodes

1. Size	Report the 3 diameters for each lymph-node (depth or AP, width or T, length or L)
2. Position	Superior, medium, inferior, in lateral-cervical position, lateral or medial to carotid artery/jugular vein, in central compartment or latero-cervical levels (from I to VI) [38]
3. Features	Typical shape/echostructure: oval shape, presence of the hilum Atypical shape/echostructure Indeterminate: round shape, absence of hilum Suspicious: solid pattern with echogenicity similar to the thyroid nodule; presence of micro-macrocalcifications; cystic or mixed appearance; irregular (chaotic) vascularization

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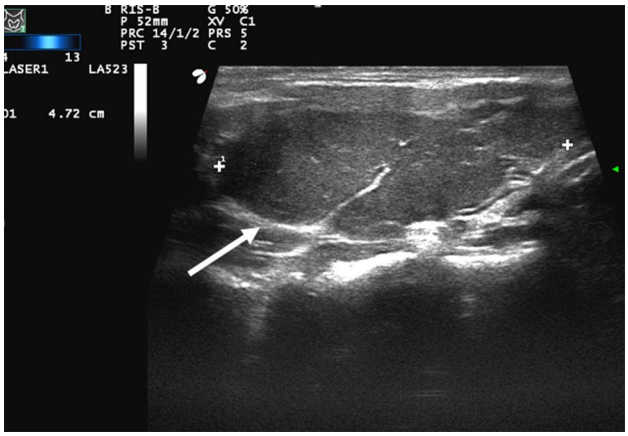

Fig. 1 Autoimmune thyroiditis. Longitudinal section: enlarged thyroid lobe with diffuse, homogeneous and moderate hypoechogenicity

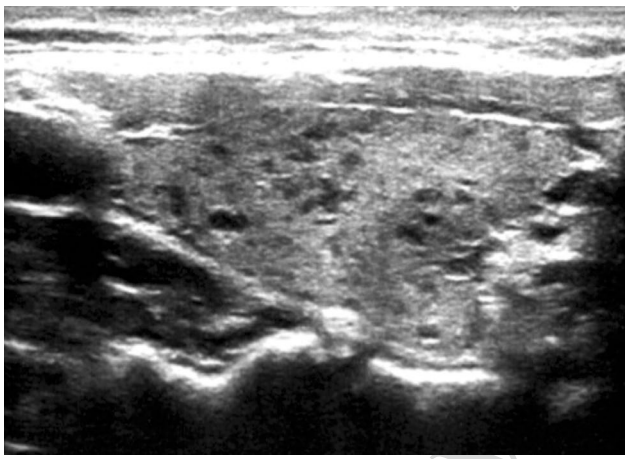

Fig. 2 Autoimmune thyroiditis. Longitudinal section: enlarged thyroid lobe with diffuse, mild hypoechogenicity

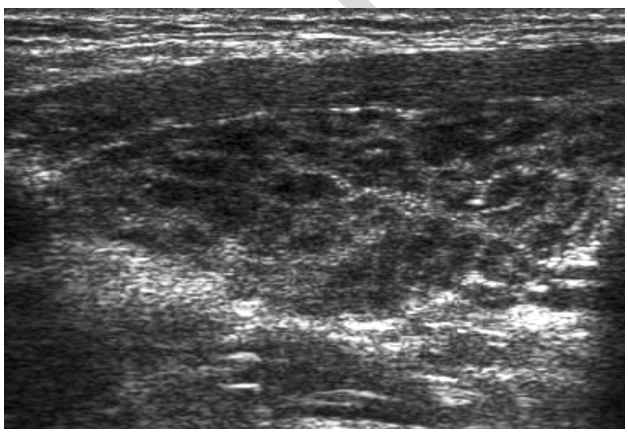

Fig. 3 Autoimmune thyroiditis. Longitudinal section: enlarged thyroid lobe with diffuse moderate hypoechogenicity, marked inhomogeneity with honeycomb appearance

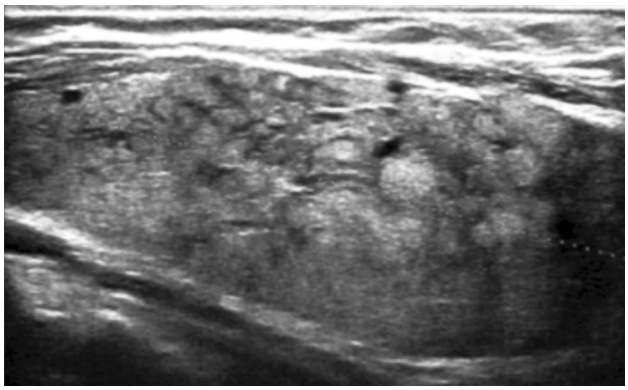

Fig. 4 Autoimmune thyroiditis. Longitudinal section: enlarged thyroid lobe with diffuse, mild hypoechogenicity with pseudo-nodular appearance

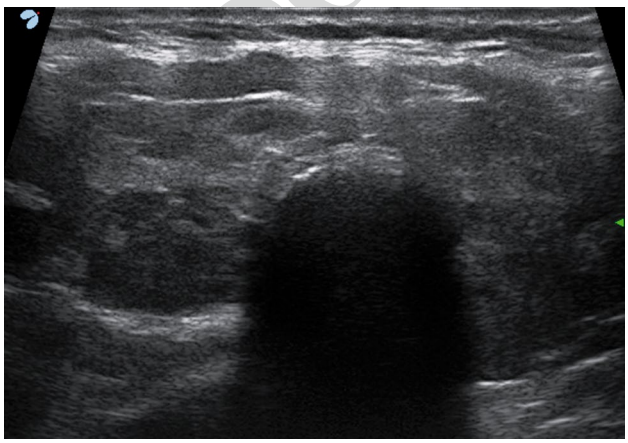

Fig. 5 Autoimmune thyroiditis. Transverse section: enlarged thyroid lobe with diffuse, moderate hypoechogenicity, marked inhomogeneity, with hypoechoic nodular area in the right lobe

for predicting the risk of developing hypothyroidism in patients with goiter and circulating thyroid autoantibodies [1, 12].

The typical US pattern of Hashimoto's thyroiditis is a hypoechoic thyroid gland with hyperechoic fibrous septa crossing the parenchyma. Lymphocytic infiltration may also cause a pseudo-nodular pattern with multiple discrete hypoechoic areas. On the other hand, solid hyperechoic areas can also be detected in a diffusely hypoechoic parenchyma representing areas spared from lymphocytic infiltration. These also are often referred to as pseudo-nodules. We recommend reporting the above findings as hypoechoic or hyperechoic areas, respectively, rather than nodules. These areas should receive a thorough examination to keep them distinguished from "true" thyroid nodules.

Table 4 US features and patterns associated with benignity

Completely anechoic texture (cystic nodules)
Mixed/spongiform texture
Oval shape
Iso/hyper echogenicity
Regular margins
Complete halo
Coarse macrocalcifications
Hyperechoic pseudo-nodular areas in thyroid autoimmune diseases
Coalescent iso/hyperechoic nodule in the context of goiter
High elasticity at elastosonography

US report in subacute thyroiditis

The diagnosis of subacute or De Quervain thyroiditis is usually made on the basis of clinical symptoms of neck pain and fever, together with laboratory findings of thyrotoxicosis and inflammation. The typical appearance of subacute thyroiditis is a diffuse heterogeneity with the presence of patchy, poorly defined hypoechoic areas that can affect a portion of one or both lobes, an entire lobe, or the entire gland [28]. These ill-defined hypoechoic areas typically change and migrate during the active phase of the disease and disappear on remission. The affected part of the gland has a decreased blood flow at color and power Doppler examination (Fig. 4).

US report in nodular thyroid disease

Thyroid US is a mainstay in the clinical assessment of nodular thyroid disease [29]. Indeed, US is essential in monitoring nodule size and echostructure and US features help defining the risk of malignancy in thyroid nodules.

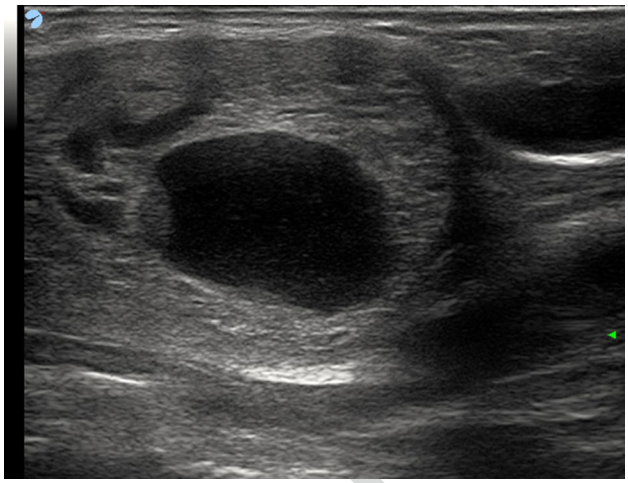

Fig. 6 Thyroid nodule with low risk: longitudinal section of right lobe. Isoechoic nodule with halo sign and cystic area

The US report in nodular thyroid disease should be structured as described in Table 2.

US report in lymph nodes

Typical lymph node is characterized by a hypoechoic pattern, oval shape and the presence of a central hyperechoic stroma corresponding to the hilum. Pathological lymph nodes have a cystic or solid pattern, iso- or hyperechoic with round or irregular shape, without hilum [37]. The position of lymph nodes that for their pattern deserve description must be precisely localized following the scheme of Robbins [38].

Table 5 Risk category

1. Low risk	Nodules with at least 2 US features associated with benignity (Table 4) and no feature associated with malignancy (Table 6)
2. Intermediate risk	Nodules with risk score 1–3
3. High risk	Nodules with risk score ≥ 4

Table 6 US features associated with malignancy

Low specificity, high reproducibility	Hypoechogenicity Thick halo	Risk score 1
High specificity, poor reproducibility	Microcalcifications Irregular, disrupted, spiculated or lobulated margins High stiffness at elastosonography	Risk score 2
High specificity, high reproducibility	Marked hypoechogenicity Irregular shape, including "taller than wide"	Risk score 3
Very high specificity, high reproducibility, accessory features	Extra capsular extension Suspicious lymph nodes	Risk score 4

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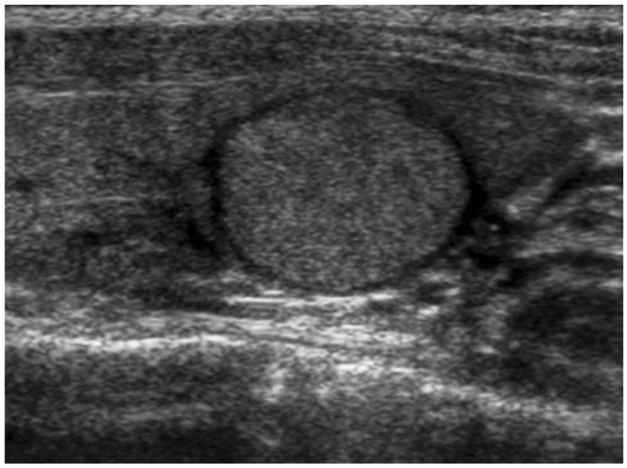

Fig. 7 Thyroid nodule with intermediate risk (risk score 2): longitudinal section of right lobe. Isoechoic nodule with thick halo and spiculated margins

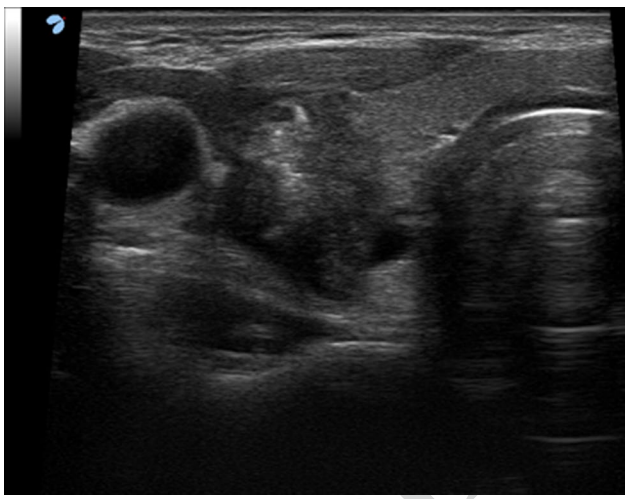

Fig. 8 Thyroid nodule with high risk (risk score > 4): transverse section of right lobe. Inhomogeneous hypoechoic nodule with irregular margins, taller than wide shape and extracapsular extension

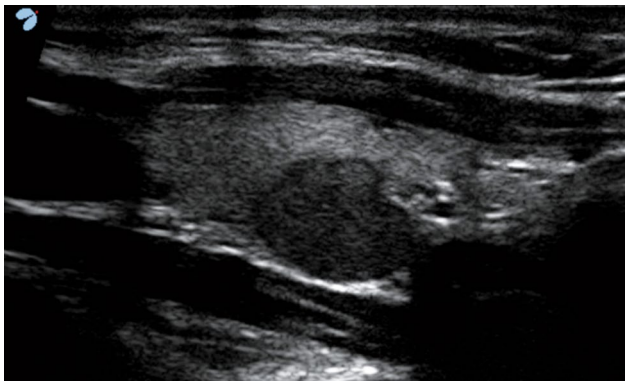

Fig. 9 Thyroid nodule with high risk (risk score > 4): longitudinal section of right lobe. Hypoechoic nodule with irregular shape and spiculated margins

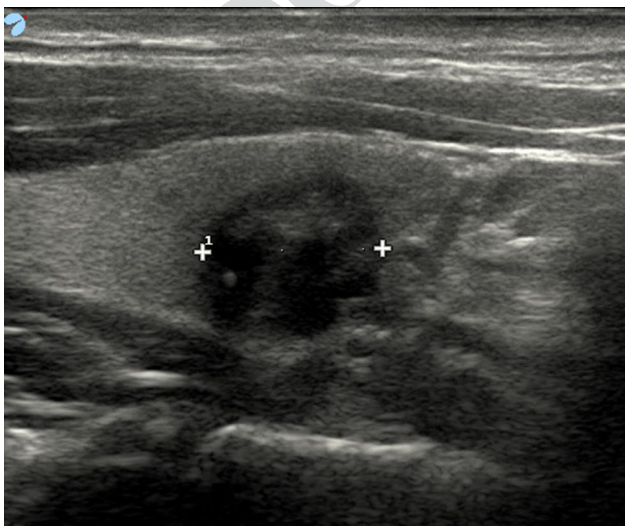

Fig. 10 Thyroid nodule with high risk (risk score > 4): Longitudinal section of right lobe. Inhomogeneous hypoechoic nodule with irregular margins and anechoic area

Risk stratification of thyroid nodules (Figs. 6, 7, 8, 9, 10, 11)

Indications for fine needle aspiration are based on the US evaluation of risk of malignancy that should be scored in each nodule. As several risk stratification systems for thyroid nodules are published, the report should include the reference of the system used.

US features and patterns suggestive of benignity are summarized in Table 4. In this consensus, we propose a simplified nodule risk stratification (Table 5), based on the predictive value of each US sign, classified and scored according to the strength of association with malignancy, but also to the estimated reproducibility among different operators (Table 6).

Conclusive remarks

Autoimmune and nodular thyroid diseases, especially in subclinical forms, are extremely frequent. Thyroid US is nowadays widely used as first diagnostic approach in such patients. The peculiar pattern of thyroid US of patients with Hashimoto's thyroiditis and Graves' disease is easily recognizable by most operators, but the terminology used to describe these patterns is not uniform, possibly causing misunderstandings in the interpretation of the reports. In the last years, several papers were focused on the possibility to

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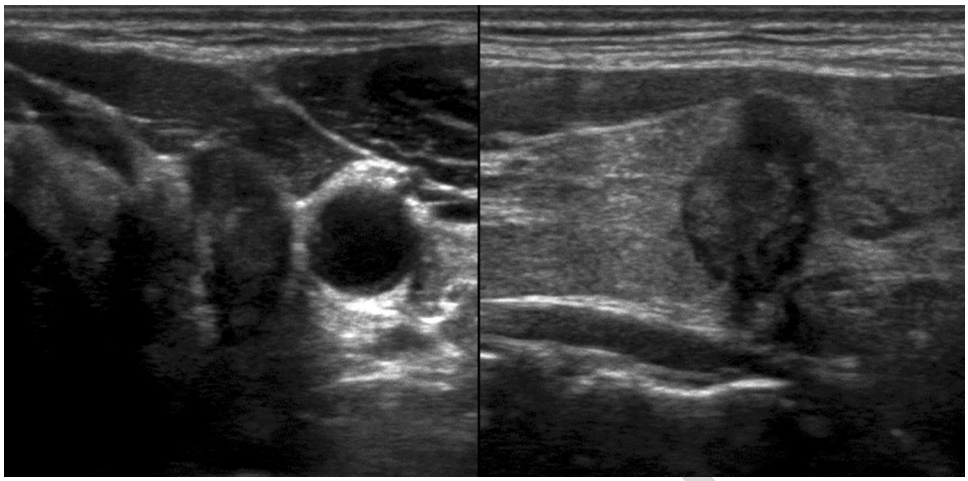

Fig. 11 Thyroid nodule with high risk (risk score > 4): transverse and longitudinal section of left lobe. Inhomogeneous hypoechoic nodule with irregular margins, taller than wide shape and extracapsular extension

stratify the risk of cancer in thyroid nodules, based on US features. Accordingly, scientific societies of endocrinologists and radiologists have drawn up guidelines and consensus statements inspired by the TIRADS system used for breast cancer. The plethora of these systems and in some cases their complexity have hampered their use in the clinical practice.

We propose here a consensus agreed by Italian scientific societies that collect specialists who deal with the diagnostic management of thyroid patients. At difference with previous publications, autoimmune thyroid diseases and subacute thyroiditis are included together with nodular thyroid diseases in the suggestion of a standardized reporting.

The hope of participating societies is that the indications contained in this consensus will be adopted by most specialists who deal with thyroid diseases, with the result of decreasing the ambiguity and inhomogeneity of thyroid US reporting.

Compliance with ethical standards

Conflict of interest The authors have nothing to disclose.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent No informed consent.

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