# Ultrasound for the assessment of thyroid nodules: an overview for non-radiologists


## Abstract

Upon discovery of a thyroid nodule (or nodules), a patient is usually referred for evaluation by ultrasound, which is typically performed by a trained radiologist or sonographer. More recently, this technology has been used intraoperatively by endocrine surgeons and also by endocrinologists, often in the context of 'one-stop shops' or point of care ultrasound in the outpatient setting. Although thyroid nodules are common and most will be benign, the subsequent work up of these can cause anxiety for patients and place a burden on radiologists. In the UK, sonographic features of benign, suspicious or malignant nodules are classified by the British Thyroid Association U1–U5 criteria, which decide whether to biopsy the nodule (typically U3 and above). This article provides an overview of ultrasound in assessing the thyroid nodule in the context of this classification. This can be used as a guide to interpretation of thyroid ultrasonography for non-radiologists.



Key words: Imaging; Thyroid nodules; Thyroid ultrasound

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## Thyroid gland anatomy

The thyroid gland is the largest endocrine organ and is located antero-laterally to the trachea in the lower part of the neck. It extends from the oblique line of the thyroid cartilage to the fifth to sixth tracheal cartilage ring. The thyroid gland weighs approximately 25 g. It is H-shaped and consists of two lateral lobes connected by an isthmus. Each lobe is 5 cm long, 3 cm wide and 3 cm thick, is pyramidal in shape and has an apex, base and three surfaces (lateral, medial and posterolateral) (Fancy et al, 2010). The isthmus has two surfaces (anterior and posterior) and two borders (superior and inferior). The thyroid gland is highly vascular and is mainly supplied by the superior and inferior thyroid artery, with venous drainage by the superior, middle and inferior thyroid veins. Innervation is from both the sympathetic (superior, middle and inferior cervical sympathetic ganglia) and parasympathetic (vagus and recurrent laryngeal) nerves. During development, the thyroid gland moves – initially near the base of the tongue, it descends down the neck to lie in its adult anatomical position. It moves through the thyroglossal duct, which normally fuses and regresses in adult life, although in 50% of individuals the distal portion of the duct continues as a pyramidal lobe, and other portions of the duct may persist as thyroglossal cysts (Chou et al, 2013; Nilsson and Fagman, 2017).

## The thyroid nodule

A thyroid nodule is an unusual growth of cells in the thyroid gland. These take different forms, including:

- Colloid nodules (an overgrowth of normal thyroid tissue). These are benign. They can be large but tend not to spread beyond the thyroid gland
- Thyroid cysts, which are benign growths filled or partially filled with fluid
- Multinodular goitre that can contain many nodules of varying sizes
- Hyperfunctioning nodules which autonomously produce thyroid hormone and can lead to hyperthyroidism
- Thyroid cancer which represents less than 5% of thyroid nodules (Dean and Gharib, 2008; Burman and Wartofsky, 2015; Gharib et al, 2016).




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The main components in the assessment of a thyroid nodule are clinical history and examination, measurement of thyroid function and antibodies (thyroid peroxidase and thyroid stimulating hormone receptor antibody), thyroid ultrasound (with or without computed tomography of the neck or thyroid) and, if indicated, fine needle aspiration or biopsy. Hot and cold nodules can be differentiated by the use of thyroid uptake and scintigraphy using $^{99m}$Tc pertechnetate, $^{123}$I-iodide or $^{131}$I-iodide. Most thyroid nodules do not produce symptoms and are often discovered incidentally during a routine exam or on imaging tests, including computed tomography and ultrasound for unrelated reasons. Occasionally, patients will discover a neck lump; if of significant size, neck lumps can sometimes produce compressive symptoms such as dysphagia, dyspnoea and hoarse voice. Some nodules can present with symptoms of hyperthyroidism if they are producing excess levels of thyroid hormones, although most are non-functioning. Thyroid nodules are common and are three times more common in women than in men. By the age of 60 years, around 50% of people will have a thyroid nodule or nodules that can be palpated clinically or seen on imaging; around 95% of these are benign (Durante et al, 2015; Yun et al, 2019).

Treatment for benign thyroid nodules can include conservative follow up with observation and serial imaging over time or they may require surgical resection (often thyroid lobectomy if benign) for cosmetic reasons or for patient preference and decompression if large and causing compressive symptoms. Other treatments include ethanol ablation and radiofrequency ablation (Muhammad et al, 2021). For nodules that are indeterminate (in that the diagnosis of being benign or malignant is unclear) on ultrasound (U3) and subsequent biopsy (Thy 3), various scoring systems have been established including thyroid imaging reporting and data systems (TIRADS), British Thyroid Association and the Bethesda scoring system, which can guide clinical decision making based on the probability of malignancy (Mistry et al, 2020; Couzins et al, 2021; McClean et al, 2021). Panels of markers have been used to rule 'out or in' indeterminate nodules. The most commonly used is the Afirma gene expression classifier, which uses microarray technology to analyse mRNA expression of 167 different genes, 142 of which are commonly, and 25 of which are uncommonly seen with thyroid cancer (Alexander et al, 2012).

## How to perform a thyroid ultrasound

Ultrasound examination of the thyroid is performed with the patient in the supine position with the neck hyperextended, typically performed in real time with two-dimensional grey-scale and Doppler modes using a high resolution 7.5–12 MHz linear array transducer. The neck is scanned in transverse and longitudinal planes of both lobes and isthmus, and imaging of the lower poles can be improved by making the patient swallow. The carotid arteries and jugular veins are noted bilaterally and the neck is examined for the presence of lymph nodes (this review does not focus on the practicalities of lymph node ultrasound). Real-time imaging of any thyroid nodules is performed in both grey-scale and colour Doppler. Imaging characteristics of the nodule or mass should be noted, including size, shape, location, echogenicity, contents and vascular pattern and aspiration or biopsy of the nodule undertaken if indicated.

## Indications for performing thyroid ultrasound

Thyroid ultrasound is widely available. More recently it is being used by endocrinologists and surgeons in outpatients and intraoperatively. Thyroid ultrasound has benefits in terms of the portability of the equipment, the fact that no ionising radiation is involved, it is not expensive and is non-invasive. Real-time imaging can help guide a clinician in diagnostic and therapeutic interventional procedures. However, it cannot determine whether the function of the thyroid gland is normal, underactive or overactive.

Indications for performing thyroid ultrasound include:

- Palpable solitary nodule
- Palpable multinodular goitre
- Suspicion of a nodule in a patient with a difficult neck examination
- Prior history of neck radiation

- Family history of medullar carcinoma, multiple endocrine neoplasia (MEN-2) or papillary thyroid carcinoma
- Unexplained cervical lymphadenopathy
- Preoperative thyroidectomy for cancer or for long-term postoperative surveillance.

## Ultrasound features of nodules being benign or malignant

Thyroid ultrasound features that indicate that the nodule is likely to be benign:

- Spongiform or honeycomb appearance making up more than 50% of the nodule
- Purely cystic nodules and nodules with a cystic component containing colloid
- Eggshell calcification around the periphery of the nodule
- The nodule is iso-echoic or mildly hyperechoic in relation to surrounding thyroid tissue and usually has a surrounding hypoechoic halo
- Peripheral vascularity on colour flow or Doppler.

Thyroid ultrasound findings that indicate that a nodule is likely to be malignant:

- A solid hypo-echoic nodule, which may contain hyperechoic foci (micro-calcification)
- An irregular pattern, intranodular vascularity and absence of associated halo
- A nodule that is taller than it is wide (anterior posterior >transverse) in the axial plane
- An irregular or spiculated margin
- Eggshell-type calcification around the periphery of a nodule with a broken calcified rim or extension of a hypo-echoic mass beyond the calcified rim.

## How to report a thyroid ultrasound

A thyroid ultrasound report should describe features that inform decision making, such as the need for a biopsy. Each centre that performs thyroid ultrasound should have a standardised template for reporting, as suboptimal documentation can impair stratification of the malignant risk of a thyroid nodule. In the UK the British Thyroid Association 'U' classification is used (Perros et al, 2014). The use of structured reporting templates (Figure 1) helps to maintain the integrity and consistency of the report. In some centres deep learning algorithms have been used in the interpretation and reporting of thyroid ultrasound scans.

**Date:**
**Indication:**
**Comparison:**
The right thyroid gland measures **AP x T x L** cm.
The left thyroid gland measures **AP x T x L** cm.
Overall the gland is **asymmetric/symmetric with/without** a prominent **right/left** lobe.
The gland has a heterogenous/homogenous texture.
In the **right/left upper/lower** lobe is a nodule that measures **AP X T X L** mm. The nodule is **solid or cystic:simple/complex/complex nodule, or spongioform nodule), hypoechoic/hyperechoic/isoechoic** and **homogenous/heterogenous.** The nodule has a regular/irregular (infiltrative) border with/without a hypoechoic rim/halo. **Calcification/ no calcification:microcalcification, eggshell, dense)** is seen. Grade **1 (none),2 (peripheral),3 (central moderate),4 (central intense)** doppler flow is seen. The thyroid nodule Ultrasound (U) Classification score is **U1-U5**

**Impression**
1.**Symmetric/asymmetric (L>R, R>L, R=L) homogenous/heterogenous** thyroid gland / **multinodular** goitre.
2. **Right/left** thyroid nodule measuring … cm in greatest dimension. This nodule has …. features. FNA undertaken.

**Follow up**
Review .. months

**Figure 1.** Thyroid ultrasound report template. AP = anteriorposterior; FNA = fine needle aspiration**;** L = longitudinal; T = transverse.

**Table 1. Scoring system for thyroid nodules**

| Score | Appearance | Example |
|---|---|---|
| U1 | No nodules, normal thyroid | *Figure 2* |
| U2 | Hyperechoic or isoechoic with halo or cystic change with ring artefact, microcystic or spongiform appearance, peripheral eggshell calcification or peripheral vascularity | *Figure 3* |
| U3 | Solid homogenous markedly hyperechoic nodule with halo (follicular lesion) or hypoechoic with equivocal echogenic foci or cystic change, or mixed or central vascularity | *Figure 4* |
| U4 | Solid hypoechoic, solid very hypoechoic, or hypoechoic with disrupted peripheral calcification or lobulated outline | *Figure 5* |
| U5 | Solid hypoechoic with a lobulated or irregular outline and microcalcification, solid hypoechoic with a lobulated or irregular outline and globular calcification, intranodal vascularity, taller than it is wide axially, or characteristic associated lymphadenopathy | *Figure 6* |

*From Perros et al (2014)*

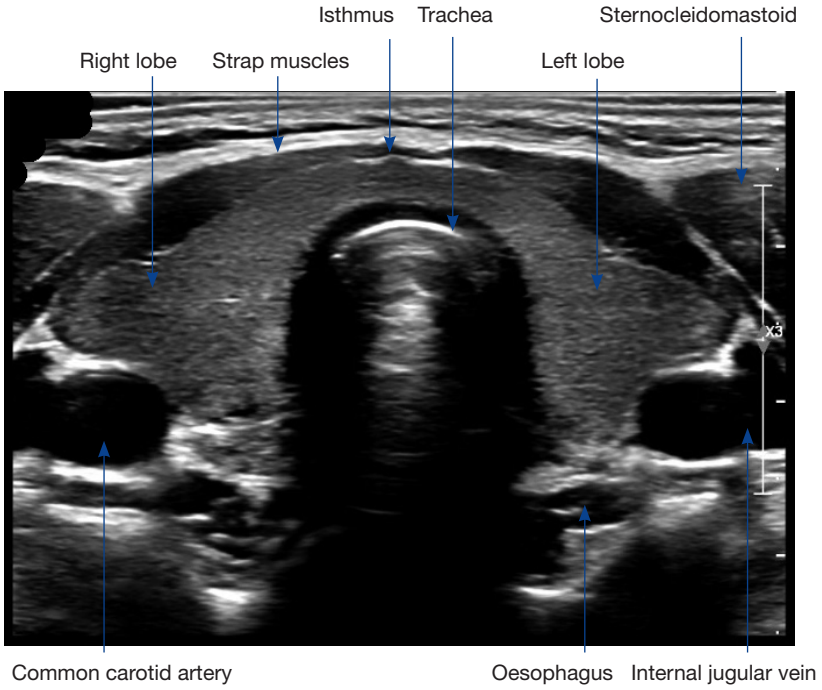


**Figure 2.** Normal thyroid anatomy.

## Imaging of thyroid nodules

The British Thyroid Association U1–5 scoring system allows for clinical decision making when performing ultrasound of thyroid nodules (Weller et al, 2020). Nodules that are classified as U3 and above are normally biopsied. The scoring system is outlined in Table 1.

## Conclusions

Ultrasound is safe, cheap and effective for the assessment of thyroid nodules. As the frequency of finding incidental thyroid nodules increases, radiologists will require additional time to perform these scans. In addition, the move towards endocrinologists and endocrine surgeons performing real time imaging is gaining momentum. Thyroid ultrasound can be performed safely and effectively by those properly trained in performing and reporting the scans. This review provides an overview for non-radiologists interested in real-time thyroid ultrasound scanning.

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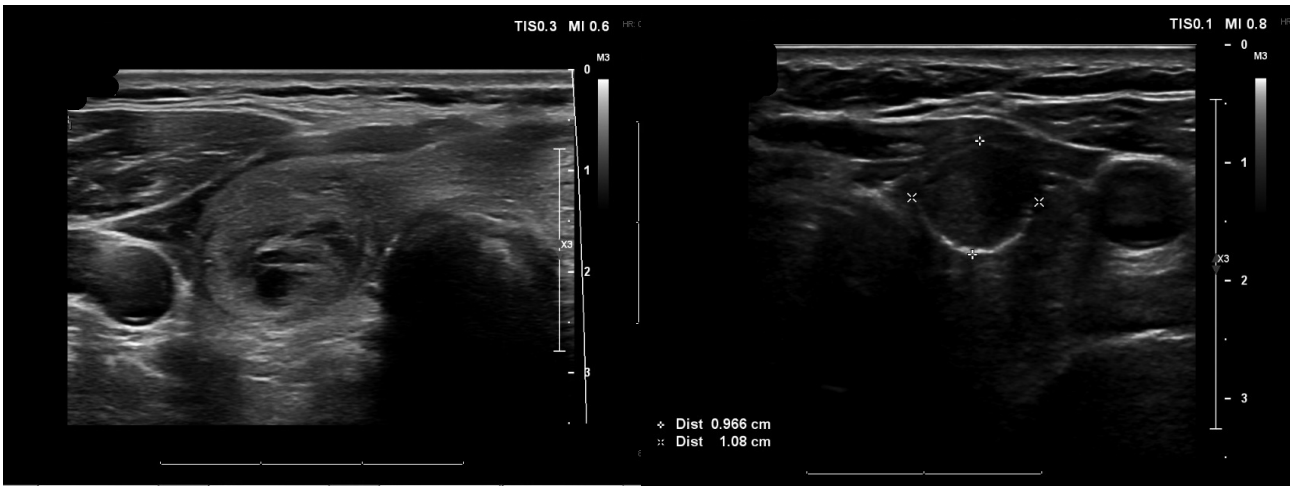


**Figure 3.** A nodule with U2 score: transverse grey-scale ultrasound demonstrating (a) spongiform appearance and (b) peripheral eggshell calcification.

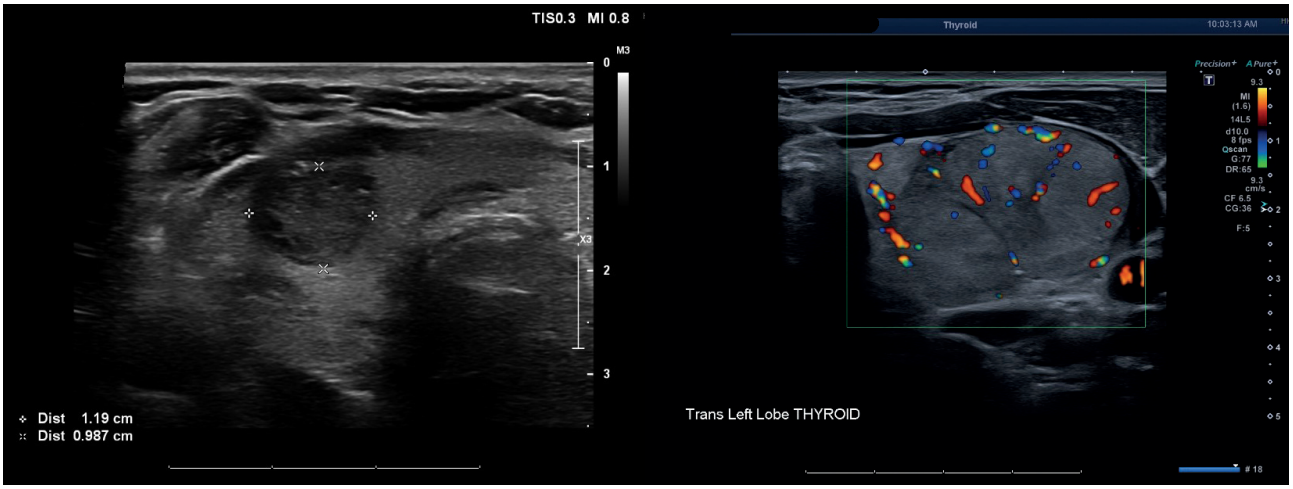


**Figure 4.** A nodule with U3 score: transverse grey-scale ultrasound demonstrating (a) hypoechoic nodule and (b) a solid nodule with central vascularity on Doppler.

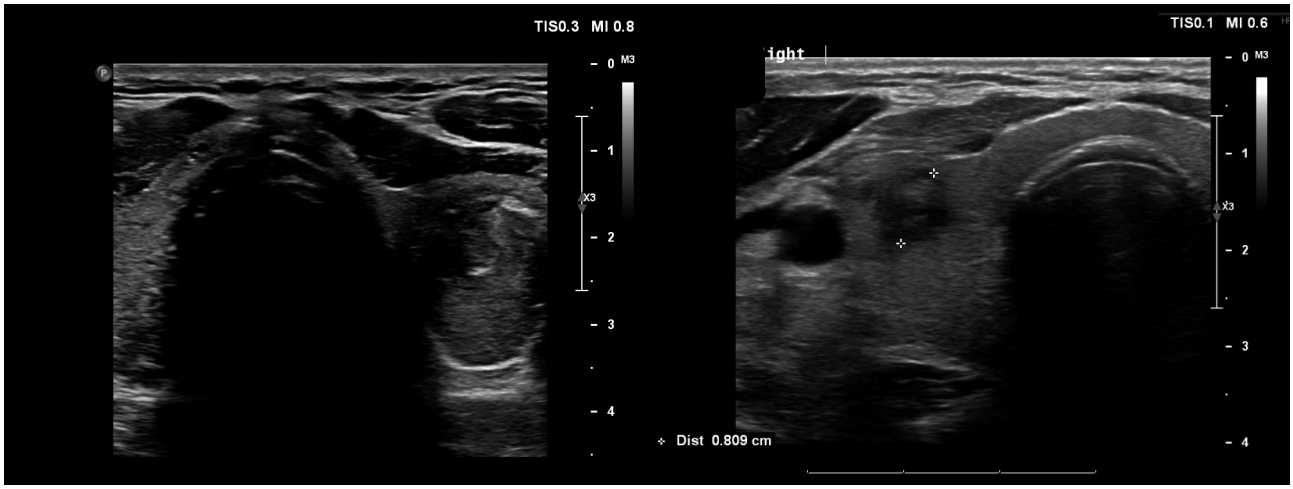


**Figure 5.** A nodule with U4 score: transverse grey-scale ultrasound demonstrating (a) a hypoechoic nodule with disrupted peripheral calcification and (b) a hypoechoic nodule with a lobulated outline.

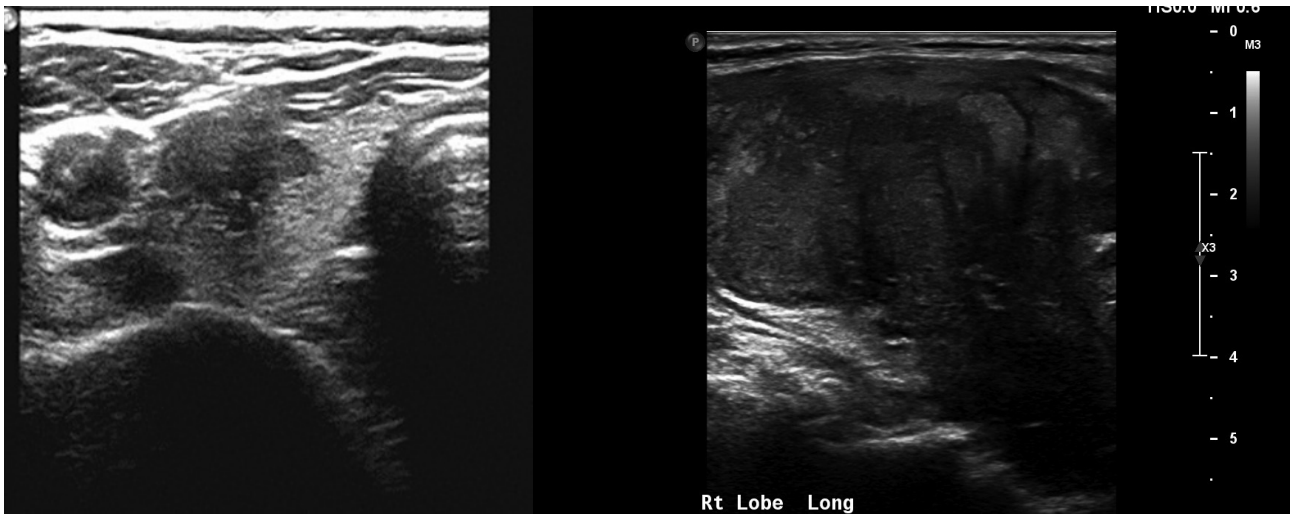


**Figure 6.** A nodule with U5 score: transverse grey-scale ultrasound demonstrating (a) a nodule with a lobulated and irregular outline and (b) a nodule with a solid hypoechoic nodule with micro-calcification.

## Key points

- Thyroid nodules are common and most are benign.
- Thyroid ultrasound scanning is typically performed by radiologists, more recently this technology had been adapted by endocrinologists.
- Thyroid ultrasound can be performed effectively by non-radiologists provided that they have adequate training and certification.

**Conflicts of interest**

The authors declare that they have no conflicts of interest.

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