Ultrasound of the thyroid

Introduction

Ultrasound has become the investigation of choice for patients with palpable thyroid gland abnormalities because of its high anatomical resolution, wide availability, low cost and lack of radiation exposure. This article reviews the indications for thyroid ultrasound, examination techniques and the sonographic features of both benign and malignant thyroid pathology. Particular emphasis is placed on the role of ultrasound, in combination with fine needle aspiration cytology (FNAC), in evaluating thyroid nodules for malignancy.

Technique

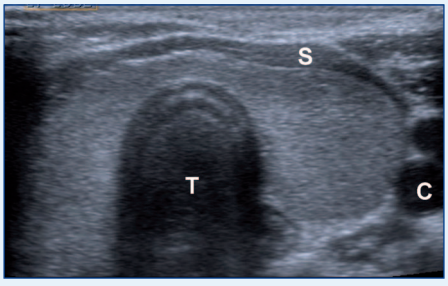
The thyroid is superficially located and can be imaged with a high-frequency linear array transducer (10–15 MHz) with a resolution of 0.7–1.0 mm. The patient is examined supine with the neck extended (a pad behind the shoulders may be helpful) and the entire gland is scanned in the longitudinal and axial planes (*Figure 1*).

The thyroid gland is echogenic relative to the adjacent structures and has a homogenous, 'ground-glass' appearance. Each lobe has a smooth contour and measures approximately 3.5 x 1.5 x 1 cm. The isthmus crosses the trachea anteriorly, measuring 2–3 mm in depth. A pyramidal lobe (arising from the isthmus in the midline) is not seen unless it is enlarged.

The gland is moderately vascular on colour flow ultrasound which is routinely used to evaluate the vascularity of nodules or enlarged glands. Special maneouvres including hyperextension of the neck or swallowing may be used to elevate the inferior portions of the thyroid gland above the clavicles. Ultrasound cannot assess the extent of retrosternal extension in a symptomatic enlarged gland (computed tomography (CT) is a more appropriate investigation).

The examination should be extended laterally to identify enlarged lymph nodes (jugular chain and supraclavicular), particularly if a suspicious nodule has been identified. The strap muscles and sternocleidomastoid lie superficial to the carotid artery and jugular vein on either side of the gland. The air-filled trachea does not transmit the ultrasound and only the anterior portion of the cartilaginous ring is represented by dense, bright echoes. The oesophagus may be demonstrated behind the medial part of the left thyroid lobe. A swallow of water can be used to confirm its position. The parathyroid glands are seen only when they are enlarged and are less dense ultrasonically than thyroid tissue because of the absence of iodine.

Figure 1. Transverse view of the normal thyroid gland which is uniformly echogenic. The trachea (T) lies immediately posterior in the midline with the strap muscles (S) anterior to the gland. The left common carotid artery (C) and left internal jugular vein are seen to the right of the image.



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Indications for thyroid ultrasound

There are differences of opinion among clinicians regarding appropriate indications for thyroid ultrasound. The American Association of Clinical Endocrinologists have published comprehensive guidelines for the management of solitary thyroid nodules (AACE/AME Task Force on Thyroid Nodules, 2006) and the suggested indications for thyroid ultrasound in *Table 1* are based on these. Thyroid sonography probably has no useful role in the management of patients who have a normal thyroid examination and no significant risk factors and the procedure is not likely to be cost-effective as a screening test. CT may be used to evaluate mediastinal or retrosternal extension of thyroid masses.

Thyroid nodules

Palpable thyroid nodules are more common in females (6.4% *vs* 1.6%) but the incidence of non-palpable nodules is at least ten-fold greater when the population is screened by ultrasonography and exceeds 50% when the thyroid gland is examined at autopsy (Mazzaferri, 1993). The prevalence of thyroid nodules increases with age and the probability that a thyroid nodule is malignant is higher in certain age groups (<20 or >60 years old), in those with a family history of thyroid carcinoma and in patients with a history of neck irradiation.

Thyroid nodules are evaluated with greyscale and colour flow imaging for fea-

Table 1. Indications for thyroid ultrasound

Recommended	Palpable thyroid nodules	
	Multinodular goitre	
	High-risk patients	History of familial thyroid cancer
		Multiple endocrine neoplasia-2
		Previous radiotherapy
	Cervical adenopathy suggestive of a malignant lesion	
Not recommended	Normal thyroid on palpation and low risk of thyroid cancer	
	Non-specific symptoms	Neck pain
		Cough, hoarseness
		Dysphagia
	Screening test in the general population	

Based on guidelines from AACE/AME Task Force on Thyroid Nodules (2006)

Table 2. Ultrasound features associated with thyroid cancer

Hypoechogenicity
Microcalcifications (particularly papillary carcinoma)
Solid with variable internal echogenicity
Irregular margins or absence of halo
Central vascularity
Growth beyond the margins of the gland
Regional lymphadenopathy

tures which are predictive of malignancy (*Table 2*). The sensitivity, specificity and predictive values of these features vary between studies and consequently FNAC is often required to exclude malignancy. A Society of Radiologists in Ultrasound consensus conference statement has proposed ultrasound criteria based on these features to select nodules greater than 1 cm in maximum diameter for FNAC (*Table 3*, Frates et al, 2005).

Ultrasound-guided FNAC is probably unnecessary if a nodule is almost entirely cystic and if a gland is diffusely enlarged with multiple nodules of similar appearance (without intervening parenchyma). However, the presence of multiple nodules is not in itself reassuring, since the risk of malignancy in a thyroid with multiple nodules is similar to that with a single nodule (Papini et al, 2002). Furthermore, nodule size alone is not reliable in predicting or excluding malignancy, despite the common practice of selecting the largest nodule in a multinodular goitre for FNAC (*Figure 2*). The AACE/AME Task Force on Thyroid Nodules suggests FNAC of nodules <1 cm if there are suspicious ultrasound features or there are risk factors. Ultrasound is often used to guide the FNAC, since it confirms that the needle tip lies within the lesion and allows it to be directed to the solid component of a complex lesion to improve diagnostic yield. Samples are classified as non-diagnostic (up to 15–20% of samples), benign, follicular, suspicious or malignant (*Table 4*). A positive result is highly specific for carcinoma, with a false-positive rate of less than 1%.

The majority of thyroid nodules (up to 80%) are benign adenomatous (hyperplastic) nodules which are usually hypofunctioning. They may occur in isolation or as part of a multi-nodular thyroid. They frequently have complex and variable features on ultrasound as a result of varying amounts of necrosis, haemorrhage, fibrosis and calcification and may be solid, cystic or mixed. Colloid nodules are also common, being formed by hyperplasia of follicular cells which then degenerate and accumulate colloid. On ultrasound they are hypoechoic with a thin wall (*Figure 3*).

Figure 2. Multinodular goitre (extended transverse view). The thyroid is enlarged (compare the width of the isthmus with* Figure 1*) and heterogenous in echotexture. A large, hyperechoic nodule (arrow) is seen in the right lobe. C = common carotid artery; T = trachea.

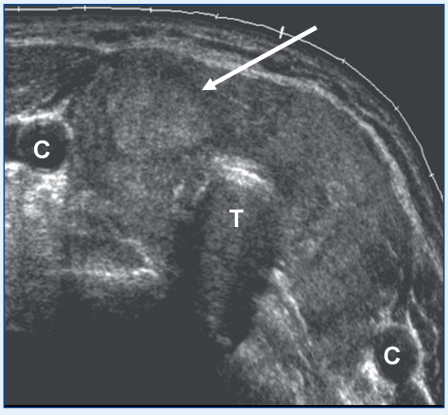


Figure 3. Colloid cyst: a round, well-circumscribed anechoic cystic thyroid lesion.

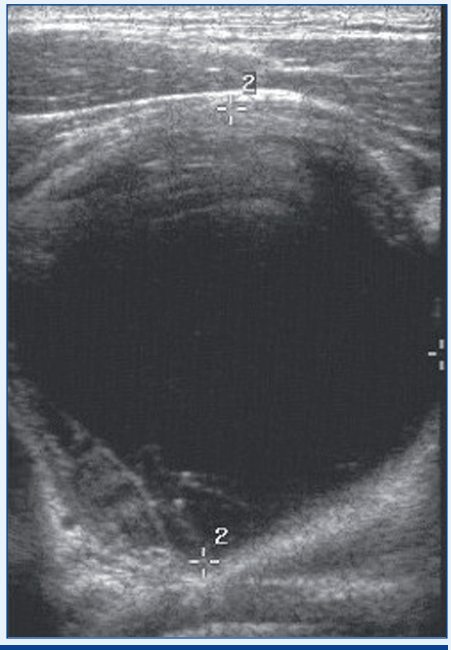


Table 3. Recommendations for thyroid nodules ≥ 1 cm in maximal diameter

Ultrasound feature		Recommendation
Solitary nodule	Microcalcification	Strongly consider FNAC if ≥ 1 cm
	Solid or coarse calcifications	Strongly consider FNAC if ≥ 1.5 cm
	Mixed solid and cystic	Consider FNAC if ≥ 2 cm
	Substantial growth since previous ultrasound	Consider FNAC
Multiple nodules		Consider FNAC of one or more nodules, selecting on basis of criteria for solitary nodules
The presence of abnormal lymph nodes makes FNAC mandatory (either of the thyroid nodule or the abnormal node)		

FNAC = fine needle aspiration cytology. Based on Frates et al (2005)

Table 4. Fine needle aspiration cytology (FNAC) diagnostic categories

FNAC category	Diagnosis	Action
Thy 1	Non-diagnostic	Repeat FNAC
Thy 2	Non-neoplastic or benign	None but consider repeat FNAC if high-risk or suspicious features on ultrasound scan
Thy 3	Follicular lesion or suspected follicular neoplasm	*Surgery: lobectomy
Thy 4	Suspicious of malignancy	*Surgery
Thy 5	Diagnostic of malignancy	*Surgery or other treatment, e.g radiotherapy for anaplastic lesions

*These cases should be discussed in a thyroid cancer multidisciplinary team meeting. Based on British Thyroid Association and Royal College of Physicians (2007)

Internal hyperechoic particles may give rise to the 'comet tail' sign which is highly specific for a benign process.

The less common follicular adenoma (15–40%) is a monoclonal tumour arising from follicular epithelium. This may have similar features to follicular carcinoma on ultrasound and FNAC, therefore surgical excision (partial thyroidectomy) and histological analysis is mandatory if follicular cells are demonstrated on FNAC. In general, follicular lesions usually appear homogeneous and hyperechoic with a well-defined hypoechoic halo (*Figure 4*).

Figure 4. Benign solid nodule: this well-circumscribed, hyperechoic nodule occupies much of the right lobe of the thyroid gland.

Table 5. Malignant thyroid lesions

Type	Frequency	Notes
Papillary	50–80%	Typically low-grade; good prognosis; early lymph node involvement
Follicular	5–40%*	Slow-growing; haematogenous spread
Medullary	5%	Parafollicular C-cells; produce calcitonin; component of MEN IIA and IIB syndromes
Anaplastic	10%	Undifferentiated with poor prognosis; elderly patients; compressive symptoms: dysphagia, stridor
Lymphoma	5%	Non-Hodgkin's lymphoma; commonly history of thyroiditis
Metastases	<1%	

*40% of tumours in iodine-deficient populations

A detailed consideration of the various subtypes of thyroid carcinoma is beyond the scope of this article, but *Table 5* summarizes some key features of the commoner tumours. Examples of malignant lesions are shown in *Figures 5* and *6a* and *b.*

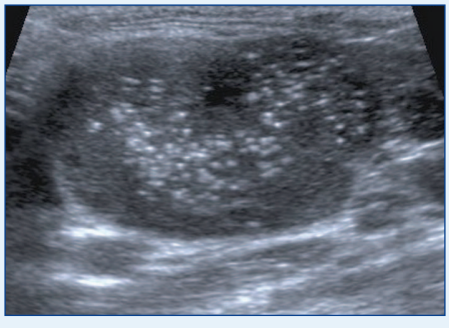
Despite the available guidelines to select nodules for FNAC, diagnostic pitfalls remain. Abnormal calcified or cystic lymph nodes adjacent to the thyroid may be misinterpreted as benign nodules within a multinodular gland: it may be possible to make a distinction on the basis of an incomplete rim of thyroid tissue around the mass or an absence of movement on swallowing. The rare, diffusely infiltrative forms of papillary and follicular carcinoma may be difficult to differentiate from benign autoimmune disease (Hoang et al, 2007).

Thyroid 'incidentalomas'

Non-palpable nodules are frequently discovered incidentally when imaging of the neck vessels is performed for vascular or neurological reasons or on CT. The appropriate management of these usually small incidental lesions remains controversial, but clearly a balance must be made between expensive over-investigation of benign nodules and any effect of delayed diagnosis on patient survival. Clinical evaluation, dedicated thyroid sonography, FNAC and occasionally even surgery may be indicated.

The risk of malignancy in palpable nodules is approximately 10%, but the risk of clinically significant tumour in incidentally detected lesions is less clear. Some investigators report a similar incidence of cancer in palpable and non-palpable thyroid nodules (Hagag, 1998; Liebeskind et al, 2005). However, whether these essentially screening-detected lesions are associated with improved survival compared to clinically-detected thyroid carcinoma is unclear. It is important to consider the low mortality of thyroid carcinoma (approximately 90% 10-year survival) when making these decisions. Autopsy studies in the general population show a prevelance of occult thyroid cancer of approximately 5%, rising to 13% if the entire gland is examined histologically. It is quite possible that many 'incidentalomas' would remain occult and be clinically insignificant (Ito et al, 2003).

Figure 5. Malignant nodule (medullary carcinoma), containing multiple bright foci of microcalcification.



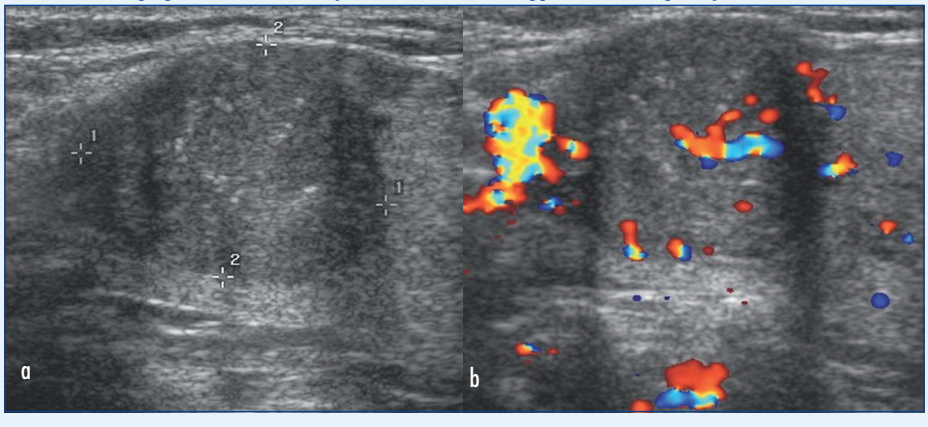
Tumour surveillance

Ultrasound is used to follow up patients after partial or complete thyroidectomy for thyroid carcinoma to assess for local recurrence or lymphadenopathy. However, ultrasound is less reliable during the first few months after surgery. During this time there may be abundant lymph nodes and heterogeneous, echogenic areas that probably reflect postoperative change.

Abnormal thyroid function

The majority of patients with clinical features of thyroid hyper- or hypofunction can

Figure 6. Malignant nodule (papillary carcinoma). a. This hypoechoic lesion contains microcalcification. b. Colour flow imaging shows well-developed internal vessels suggestive of malignancy.



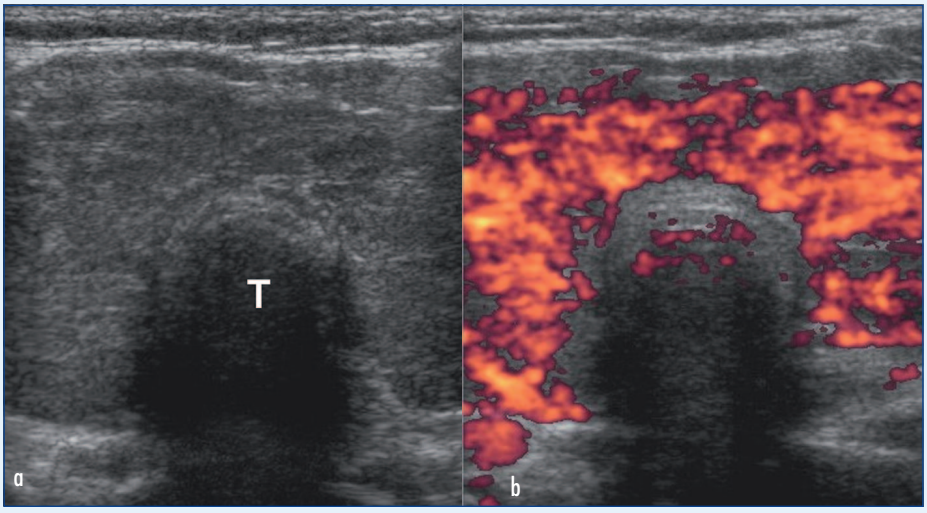


Figure 7. Graves' disease. a. The thyroid gland is diffusely enlarged and heterogenous in echotexture on the greyscale transverse image. b. Power Doppler imaging demonstrates marked hypervascularity.

be managed without recourse to ultrasound. Scintigraphy may be performed in the context of biochemically confirmed hyperthyroidism to identify a solitary hyperfunctioning nodule or diffusely hyperfunctioning gland, but Graves' disease is often a clinical and biochemical diagnosis. Ultrasound is occasionally used to confirm that the gland is involved in a diffuse process. Usually the thyroid is diffusely enlarged and relatively hypoechoic. The striking hypervascularity which may be apparent on colour flow imaging has been referred to as a 'thyroid inferno' (*Figure 7a* and *b*).

Thyroiditis

Autoimmune (Hashimoto's) thyroiditis is the commonest form of thyroiditis and predominantly affects elderly females. The clinical picture and serum thyroglobulin antibodies and thyroid peroxidase confirm the diagnosis but ultrasound appearances are of an enlarged, heterogenous, predominantly hypoechoic gland. Avascular nodules may be seen, correlating with areas of lymphocytic infiltration. Eventually fibrosis occurs and the gland decreases in size as the disease progresses. Patients remain at risk of subsequent lymphoma, leukaemia and papillary cell carcinoma and may be followed up with ultrasound.

Reidel's thyroiditis is a chronic inflammatory process and is typically self-limiting. Dense inflammatory fibrous tissue infiltrates the gland and surrounding structures, which may be difficult to distinguish from invasive carcinoma on ultrasound. Magnetic resonance imaging may be helpful in this context. Subacute viral thyroiditis (De Quervain's thyroiditis) and the much rarer acute bacterial suppurative thyroiditis are also recognized, the latter usually being associated with a congenital pyriform sinus fistula.

Developmental abnormalities

Thyroid ectopia or agenesis are best assessed by scintigraphy. Ultrasound is helpful to evaluate thyroglossal duct cysts which are located anywhere in the midline from the foramen caecum at the tongue base to the anterior mediastinum. They are typically anechoic but may become more echogenic if infected (*Figure 8*). Rarely, papillary carcinoma has been described arising from them. **BJHM**

Conflict of interest: none.

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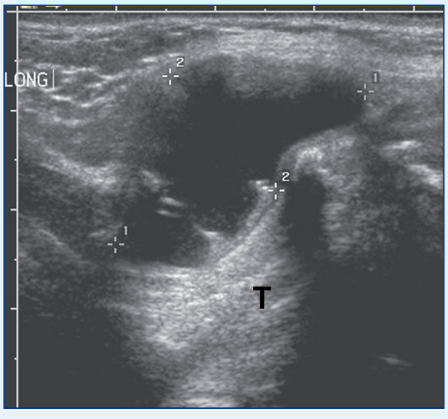
Figure 8. Thyroglossal cyst. This longitudinal midline view shows a cystic structure immediately anterior to the thyroid cartilage (T). The cyst moved on swallowing and when the tongue was protruded. A tract was demonstrated extending inferiorly to the thyroid.



KEY POINTS

- Ultrasound is the investigation of choice for patients with palpable thyroid gland abnormalities because of its high anatomical resolution and lack of radiation exposure.
- Certain ultrasound features of a thyroid nodule are suggestive of malignancy, including hypoechogenicity, microcalcification and internal vascularity on colour flow imaging.
- Ultrasound cannot reliably differentiate between benign and malignant lesions. Fine needle aspiration cytology is needed to make the distinction in many cases.
- The decision to perform fine needle aspiration cytology on an incidental thyroid nodule should be made on the basis of the ultrasound appearances and the presence of clinical risk factors for carcinoma.
- The majority of patients with clinical features of thyroid hyper- or hypofunction can be managed without recourse to ultrasound.