The recommended protocol for thyroid ultrasound is in the American College of Radiology Practice Guideline [(2)], which is as follows:

1. Transverse scans of the whole gland at the upper, mid and lower poles and the isthmus, and side-by-side images of each lobe, to compare echogenicity and size of both lobes. Each lobe width and anteroposterior diameters are measured [Figure 2a].
2. Longitudinal scans through each lobe on medial, mid and lateral planes. The length of the lobes is measured [Figure 2b].
3. Identify focal lesions, measure the main lesions and identify the dominant one (according to size).
4. Document the presence of enlarged lymph nodes or thrombosed jugular vein.

Standardised ultrasound reporting criteria should be followed indicating the position, shape, size, margins, content, echogenicity and vascular pattern of the whole gland and, when present, the focal lesions. Nodules with malignant potential should be identified and FNA biopsy should be suggested to the referring physician.

Figure 2 Thyroid measurement on (a) transverse and (b) longitudinal scans.

a

b

Normal anatomy

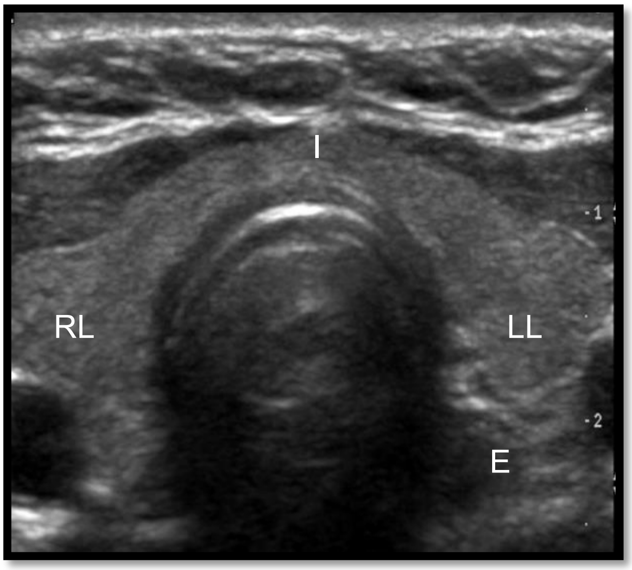
The normal thyroid is comprised of two lobes and the isthmus, which bridges the lobes in front of the trachea. Size and shape are variable depending on the age of the patient (Table 1). It has a medium to high-level echogenicity. The relationships with the surrounding structures are as follows: ahead, the strap muscles and sternocleidomastoid muscle; behind, the trachea and longus colli muscles bilaterally, the common carotid artery and jugular vein and finally, the oesophagus lies behind the left thyroid lobe [Figure 3].

Table 1 Normal thyroid dimensions. A-P, anteroposterior; SD, standard deviation

Age	Longitudinal	A-P	Volume	Isthmus
Newborn	18-20 mm	8-9 mm		
1 year old	25 mm	12-15 mm		
Adult	40-60 mm	13-18 mm (up to 20 mm)	18.6 mL or gram (SD:4.5) M: 19.6 (4.7) F: 17.5 (4.2)	4-6 mm A-P

Figure 3 **Normal thyroid and surrounding structures on transverse scans. RL, right lobe; LL, left lobe; I, isthmus; E, esophagus; T, trachea; SM, strap muscles; SCM, sternocleidomastoid muscle; JV, jugular vein; CCA, common carotid artery.**

a



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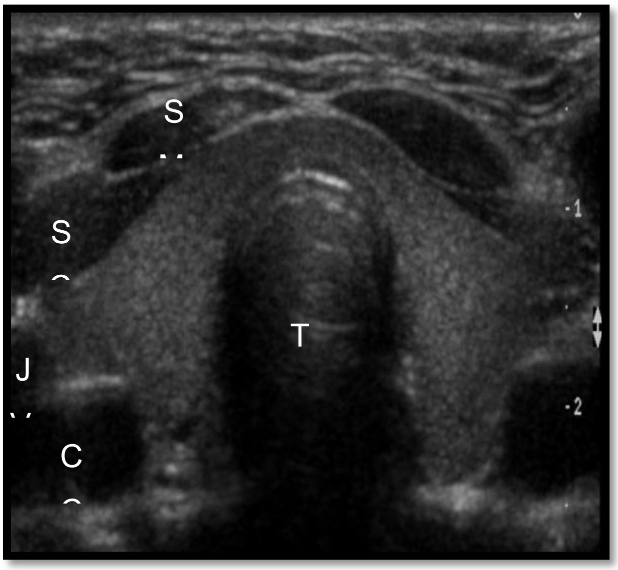
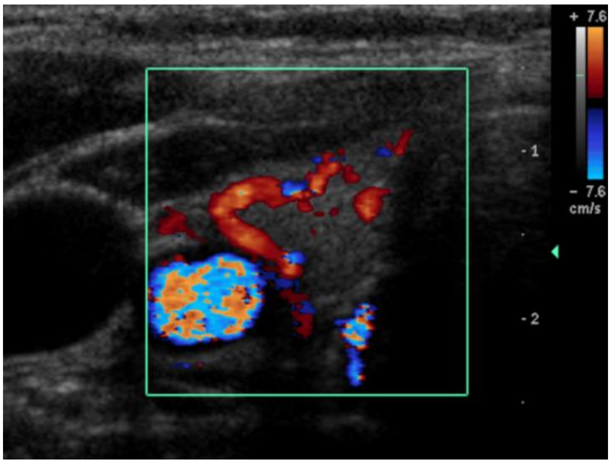


Colour and power Doppler ultrasound are useful in the evaluation of vascularity of the thyroid gland and focal masses. The thyroid gland is a richly vascularised organ. The arterial supply is provided on each side by the superior thyroid artery (a branch of the external carotid artery) and the inferior thyroid artery (a branch of the thyrocervical trunk, which is a branch of the subclavian artery). The thyroid arteries may be localised on colour or power Doppler. Low-resistance flow is demonstrated on spectral Doppler in these visceral arteries. A peak systolic velocity in the intra-thyroid arteries is in the range of 15–30cm/s and is the highest velocity found in any superficial organ [Figure 4].

Figure 4 **Arterial vascularisation of the thyroid gland. On colour Doppler imaging the inferior thyroid artery is seen (a). On spectral display a low-resistance flow with a high systolic velocity is obtained (b).**

a



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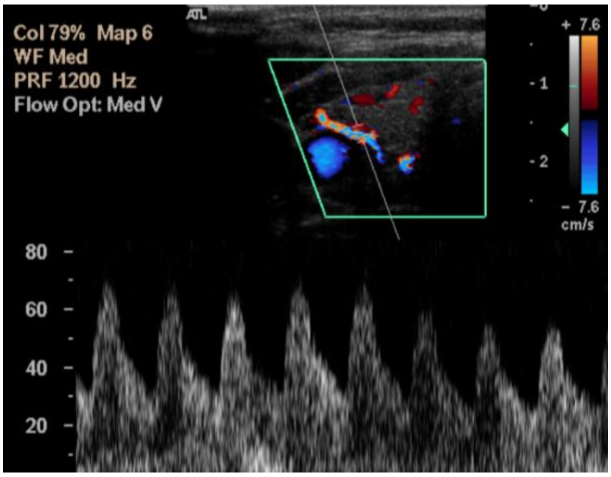


Congenital anomalies

Congenital agenesis or hypoplasia of the thyroid gland may include the whole gland or just one of the lobes. The aortic sac of the heart descends and pulls the thyroid caudally from its origin at the base of the tongue [Figure 5], its pharyngeal connection elongates as a stalk (the thyroglossal duct), which normally disappears in the fifth to sixth week of intrauterine life. Ectopic thyroid, a deficit in migration of the thyroid gland to the lower neck, commonly develops at a sublingual or a suprahyoid position. Ectopic thyroid can be easily detected on radionuclide scans [Figure 6].

Figure 5 Congenital developmental defects and clinical outcomes. Development of the thyroid gland begins in the first and second weeks of intrauterine life and is complete by week 11. The thyroid gland arises as an endodermal thickening at the junction of the developing anterior and posterior tongue, at the level of the foramen caecum, between the first and second branchial arches (from [] Mewly J et al, Radiographics 2005;25:931-948, with permission).

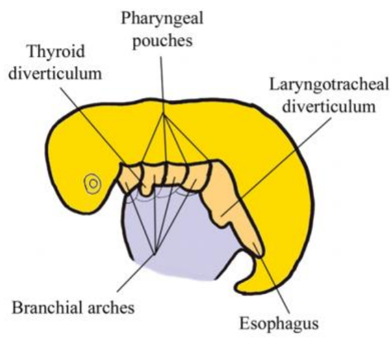
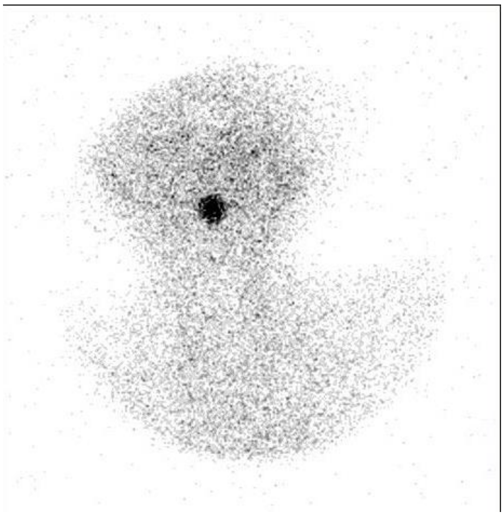


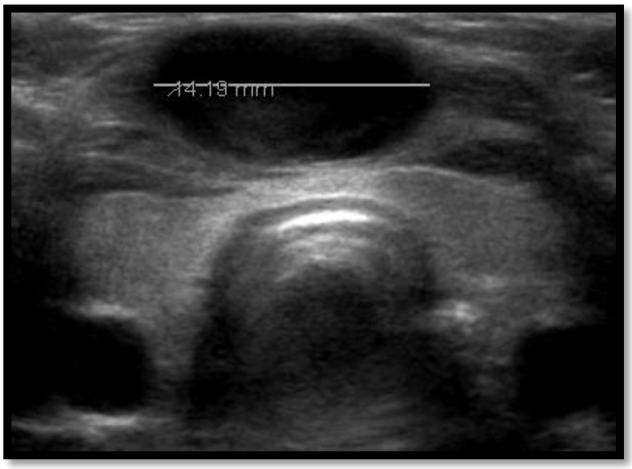
Figure 6 Ectopic (sublingual) thyroid seen on thyroid scintigraphy (I^{123}).



A thyroglossal cyst, forming from a persistent thyroglossal duct, appears as a neck lump in the midline [Figure 7]. A normally positioned thyroid gland must be examined to exclude thyroid agenesis. In the absence of a normal thyroid the cyst will be the only thyroid tissue present.

Figure 7 Midline neck lump in a 2 year old male. Normal thyroid gland at the base of the neck is present (a). A cyst (cursors) is seen ahead of the isthmus of the gland. The cyst (arrow) is demonstrated between the thyroid isthmus and the hyoid bone (b). The submandibular salivary gland (SG) is shown above the cyst. A thyroid radionuclear scan was performed pre-operatively to confirm that the thyroid gland was present and functioning normally.

a



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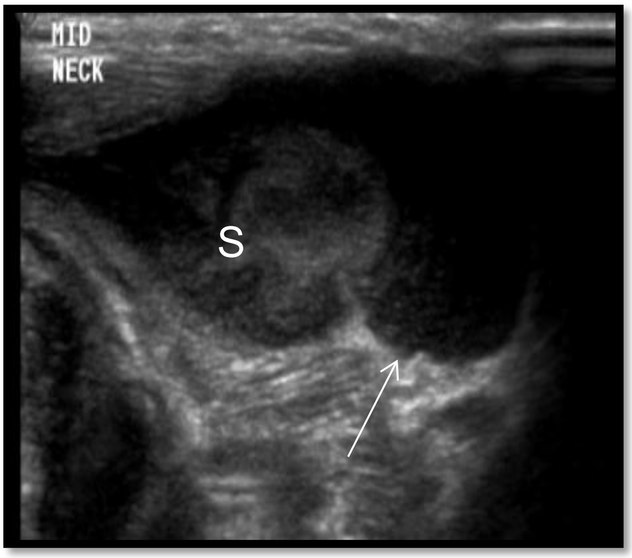
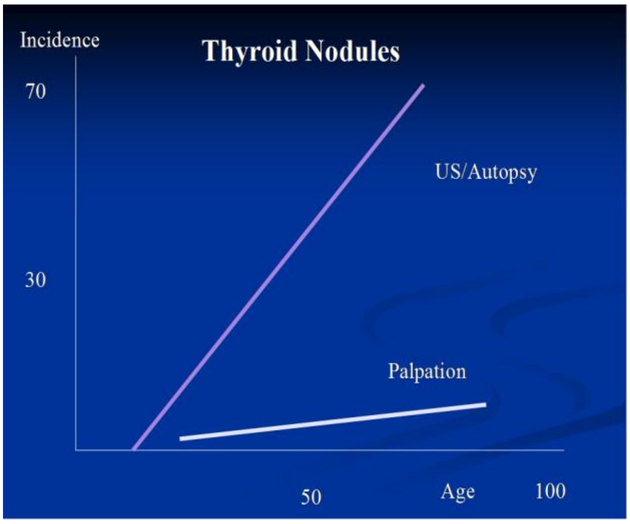


Benign thyroid nodules

Nodularity

The development of nodules can be regarded as a normal part of the maturation process of the thyroid. The incidence correlates directly with age [Figure 8].

Figure 8 Incidence of thyroid nodules (*y*) at ultrasound (US)/autopsy and on palpation related to patient age (3).

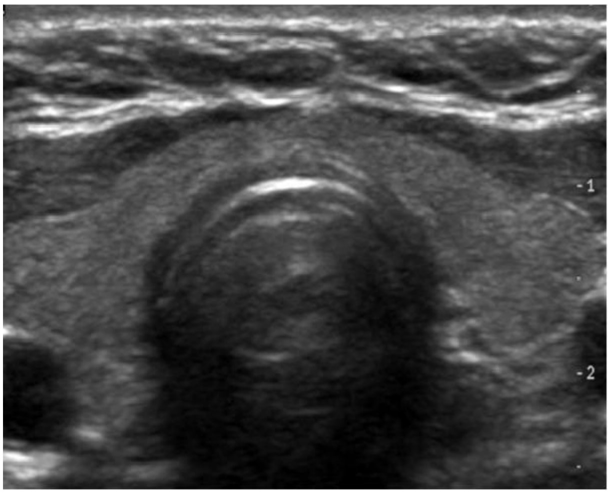


Ultrasound is an extremely sensitive tool for the detection of nodules and is equal to that of pathologists at post-mortem. There is a 30–70% incidence of thyroid nodules on ultrasound examination, depending on the age of the patient population. However, while the incidence of nodularity within the thyroid is high, the incidence of thyroid cancer is low. In the United Kingdom, the quoted incidence of thyroid carcinoma is 1 per 50000 patients per annum. Therefore, a radiologist or thyroid surgeon working in a large hospital with a catchment population of 500,000 patients would expect to see only 10 new cases of thyroid cancer a year. However, a radiologist could reasonably expect to see thyroid nodules in approximately half of the patients scanned each year. The dilemma for the radiologist or sonographer is how to identify the few thyroid cancers present within a multitude of benign thyroid nodules.

Fortunately, there are some well-documented signs that can be used in the differentiation of benign from malignant thyroid nodules on ultrasound. Thyroid nodules are formed as a result of hyperplasia and involution within the thyroid. These hyperplastic nodules frequently undergo a process of cystic degeneration *i.e*. they contain cystic areas as they mature. As the nodules evolve, haemorrhage may occur within the nodule that can increase the cystic component [Figure 9].

Figure 9 **Thyroid nodularity. Normal thyroid with an uncommon absence of nodules (a). Iso- and hyperechoic benign thyroid nodule with a halo present and cystic degeneration (b).**

a



b