Thyroid and parathyroid ultrasound

Cristina Ghervan

Endocrinology Department, University of Medicine and Pharmacy “Iuliu Hațieganu”, Cluj-Napoca, Romania

Abstract

Thyroid ultrasound is easy to perform due to the superficial location of the thyroid gland, but appropriate equipment is mandatory with a linear high frequency transducer (7.5 – 12) MHz. Some pathological aspects of the thyroid gland are easily diagnosed by ultrasound, like the enlargement of the thyroid volume (goiter) or the presence of nodules and cysts; while other aspects are more difficult and need more experience (diffuse changes in the structure, echogenicity and vascularization of the parenchyma, differential diagnosis of malignant nodules). Ultrasound has become the diagnostic procedure of choice in guidelines for the management of thyroid nodules; most structural abnormalities of the thyroid need evaluation and monitoring but not intervention. A good knowledge of the normal appearance of the thyroid gland is compulsory for an accurate ultrasound diagnosis.

Keywords: thyroid gland, parathyroid glands, cervical lymph nodes, ultrasonography.

The thyroid gland is situated in the anterior cervical region. It has a butterfly shape with two lobes connected by an isthmus and it is attached to the laringo-tracheal duct, following its movement during swallowing. Real-time ultrasound was introduced in the 80’s and rapidly proved to be the most sensitive and efficient method to evaluate thyroid anatomy as well as the abnormalities in thyroid volume, structure and echogenicity [1].

Ultrasound examination is performed with the patient in a supine position, with the neck slightly overextended by a pillow under the shoulders. High frequency linear transducers must be used (at least 7.5 MHz). Doppler (color and power) evaluation is recommended for a good diagnosis because the thyroid is a highly vascular organ, and the vascularization changes during pathological diffuse or nodular processes [2]. The ultrasound examination of the thyroid should always include the entire neck, looking for abnormal lymph nodes, enlarged parathyroid glands and abnormal masses. Both lobes must be scanned individually in the transverse and longitudinal planes [3]. Transverse planes are perpendicular to the tracheae (fig 1a), whereas longitudinal planes are slightly oblique, fol-
lowing the bisector of the angle made by the tracheae and the sternocleidomastoid muscle (fig 1b). Recurrent transverse sections are required in order to detect intrathoracic goiter, or parathyroid adenoma with ectopic location into the anterior mediastinum (fig 1c). Longitudinal retrotracheal sections can be used to detect parathyroid adenoma with ectopic retrotracheal location (fig 1d).

A normal thyroid lobe on transverse section has a triangular shape, with three edges. The structure is granulated (ground glass appearance) and the echogenicity is similar to that of the parotid glands, and higher compared to that of the vicinity muscles (fig 2).

The antero-lateral face is bordered by the strap muscles (sternohyoid, sternothyroid) that have a fibrillar structure and are hypoechoic compared to the thyroid. The sternocleidomastoid muscle is situated lateral to the most lateral point of the thyroid lobe. The muscles are covered by the fascia cervicalis, the platysma muscle and the skin.

The postero-lateral face is in contact with: the internal jugular vein, the parathyroid glands (usually not seen, unless they are enlarged), the vagus nerve (not seen in sonography), the internal carotid artery, and the longus colli muscle. The left lobe is also in contact with the esophagus which can be mistaken for a thyroid nodule, but real-time ultrasound reveals the peristalsis in the esophagus when the patient is asked to swallow.

The medial face is in contact with: the trachea, the recurrent nerve (not seen in sonography) and the inferior thyroid artery. In fact, on the ultrasound image, only the anterior wall of the trachea is visible; behind it we see the acoustic shadowing created by the extreme reflection from the tissue-air interface. Sometimes a reverberation artifact can be seen: numerous parallel lines behind the anterior wall of the trachea that are commonly mistaken for tracheal rings, but are actually reverberation artifacts (fig 3).

![Fig 1](image1.png)

**Fig 1.** a) Transverse section of the thyroid; b) Longitudinal section of the right thyroid lobe; c) Recurrent section for the view of anterior mediastinum; d) Retro tracheal section.

![Fig 2](image2.png)

**Fig 2.** Transverse view of the thyroid: SK = skin, PM = platysma muscle, FC = fascia cervicalis, SHM sternohyoid muscle, STM = sternothyroid muscle, SCM = sternocleidomastoid muscle, ISM = isthmus, TH = trachea, RTL = right thyroid lobe, LTH = left thyroid lobe, JV = jugular vein, CA = carotid artery, ESP = esophagus, LCM = longus colli muscle.
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length, then the volume is calculated by the formula \( V = \frac{W \times D \times L \times p}{6} \). The total volume results from the sum of the two volumes; the isthmus is omitted, unless its thickness is over 3 mm. The width and depth are measured on transverse section of the lobe: the width is the distance between the most lateral point of the lobe and the acoustic shadowing of the trachea and the depth is the maximum anterior-posterior distance in the middle third of the lobe (fig 5).

Fig 3. Transverse view: reverberation artifact behind the trachea wall (white arrows).

Fig 4. Longitudinal view: PM = platysma muscle, FC = fascia cervicalis, SHM = sternohyoid muscle, STM = sternothyroid muscle, TL = thyroid lobe, LC = longus colli

On longitudinal section, the thyroid lobe has an ovoid shape (fig 4). The anterior face is covered by the strap muscles and the posterior face is in contact with the elements described previously. In some cases, vessels can be detected within the parenchyma, in longitudinal or transverse section. Their differentiation from small cysts is possible with color or power Doppler examination showing blood flow in the vessels.

The volume of the thyroid gland is quite important for the current practice: it identifies the enlargement of the thyroid gland (goiter) and its response to suppressive therapy. In Graves’ disease it allows a rigorous calculation of the radio-iodine dose. Diminution of the thyroid volume (thyroid atrophy) can be detected in some cases, but has less clinical importance. Measurement of the thyroid lobe involves three measurements: the width, depth and length, then the volume is calculated by the formula \( V = \frac{W \times D \times L \times p}{6} \). The total volume results from the sum of the two volumes; the isthmus is omitted, unless its thickness is over 3 mm. The width and depth are measured on transverse section of the lobe: the width is the distance between the most lateral point of the lobe and the acoustic shadowing of the trachea and the depth is the maximum anterior-posterior distance in the middle third of the lobe (fig 5).

The length is measured on longitudinal section and it is the maximum distance from the most cranial to the most caudal part of the lobe. Measuring the length of the thyroid lobe is sometimes difficult, because most modern small parts transducers have a footpad of 4 cm or less, while the length of the thyroid lobe in adults is frequently over 4 cm. If the lobe is longer than the transducer, a “split screen technique” can be used to determine the length (fig 6).
Thyroid volume varies with the sex, age and geographic region. The right volume is slightly larger than the left one, in right handed people. In some cases, on the upper margin of the isthmus there is an accessory lobe (Lalouette pyramid) which must be identified and measured, and the volume must be added to that of the lobes. The limits of the normal thyroid volume are 10-15 ml for women and 12-18 ml for men. In children the upper limits of the thyroid volume, as they were determined by the ThyroMobile study [4] are presented in table I.

The thyroid vascular network can be evaluated by Color Doppler and by Power Doppler ultrasound. The normal appearance of the vascular network is restricted to the main thyroid vessels and their branches.

Thyroid arteries (superior thyroid artery, inferior thyroid artery) can be observed for each lobe (fig 7), along with their three branches (anterior, posterior and medial). The anastomosis of the medial branches gives rise to the superior and inferior arcades of the isthmus. In normal conditions the parenchyma arteries are not visible, but they become visible in pathological conditions characterized by enhanced vascularity, such as Graves’ disease or Hashitoxicosis. The vascular network of the thyroid nodules is also very valuable in distinguishing the rare malignant nodules from the high amount of benign ones [5]. Aside from visualization of the thyroid vascular network, flow parameters can be measured at the level of the inferior thyroid artery: peak systolic velocity (PSV), volume flow, resistive index and pulsatility index. The most used to characterize thyroid blood flow is the PSV. The normal values in the inferior thyroid artery are 20-25 cm/sec (fig 8), but it can rise in certain pathologies (Graves’ disease, Hashitoxicosis) over 100 cm/sec [6]. The follow-up of the flow parameters gives valuable information concerning the evolution and the prognosis of these diseases.

The parathyroid glands are located on the posterior face of the thyroid lobes, in extra capsular position. There are four glands, two on each side. The superior parathyroid glands are located at the level of the superior third of the lobes; whereas the inferior parathyroid glands are located at the inferior poles of the lobes. Due to their embryological origins, the inferior parathyroid glands are more likely to be ectopic into the mediastinum or in retro tracheal position. Normal parathyroids are very small (3/4/5 mm) and can be identified only with high frequency transducers (fig 9) which are not currently employed in practice; therefore, a parathyroid gland that is visible in sonography is very suspicious to be pathological (parathyroid adenoma, hyperplasia or parathyroid carcinoma).

Table I. Upper limits of the thyroid volume in children

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thyroid volume in boys (ml)</td>
<td>5.4</td>
<td>5.7</td>
<td>6.1</td>
<td>6.8</td>
<td>7.8</td>
<td>9.0</td>
<td>10.4</td>
<td>12</td>
<td>13.9</td>
<td>16</td>
</tr>
<tr>
<td>Thyroid volume in girls (ml)</td>
<td>5</td>
<td>5.9</td>
<td>6.9</td>
<td>8</td>
<td>9.2</td>
<td>10.4</td>
<td>11.7</td>
<td>13.1</td>
<td>14.6</td>
<td>16.1</td>
</tr>
</tbody>
</table>

Fig 7. Power Doppler view of the carotid artery and the inferior thyroid artery: LTL = left thyroid lobe, CA = carotid artery, ITA = inferior thyroid artery, ESP = esophagus.

Fig 8. Flow parameters: peak systolic velocity (PSV) in the inferior thyroid artery.
The diameters, shape, contour, echogenicity and homogeneity of the parathyroids must be evaluated [7]. The vascularization of parathyroid glands is made by a unique artery for each gland, emerging from the inferior thyroid artery (for the inferior parathyroid glands) and mostly from the inferior thyroid artery for the superior parathyroids (in only 10% of the cases superior parathyroid arteries emerge from superior thyroid artery). This is very important for the detection of abnormal parathyroid glands, and for their differentiation from a thyroid nodule [8].

Lymph nodes of the anterior and lateral regions of the neck must be investigated especially when a suspicious nodule is detected in the thyroid. Normal lymph nodes are small (< 1 cm), hypoechoic, with a central hyperechoic line representing the vascular hilum (fig 10). The lymph nodes number and location must be evaluated by screening all the compartments of the anterior and lateral cervical region, along with their diameters and ratio, their shape, structure and echogenicity [9]. Pathological lymph nodes can be inflammatory or metastatic and they display some characteristic features [9,10], which are beyond the scope of this paper.

In conclusion, a good knowledge of the normal appearance of the thyroid gland, parathyroid glands and cervical lymph nodes is compulsory for an accurate ultrasound diagnosis. In this paper we have tried to provide the basic notions, but frequent practice of thyroid ultrasound and knowledge of thyroid pathology and its ultrasound features will gradually improve the quality of your ultrasound diagnosis.

Fig 9. Longitudinal view - normal parathyroid glands: TL = thyroid lobe, SPT = superior parathyroid gland, IPT = inferior parathyroid gland, ES = esophagus. Doppler color view in order to differentiate IPT from a blood vessel.

Fig 10. Cervical lymph nodes.

References

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