Sonography of Normal and Abnormal Thyroid and Parathyroid Glands

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\textbf{Abstract}

Ultrasonography (US) represents the most sensitive and efficient method for the evaluation of the thyroid and parathyroid glands. Infectious and autoimmune thyroiditis are common diseases, usually diagnosed and followed up by clinical examination and laboratory analyses. Nevertheless, US plays an important role in confirming diagnoses, predicting outcomes and, in autoimmune hyperthyroidism, in titrating therapy. Conversely, in nodular thyroid disease US is the imaging method of choice for the characterization and surveillance of lesions. It provides consistent clues in predicting the risk of malignancy, thus directing patient referral for fine-needle aspiration (FNA) biopsy. Suspicious US features generally include marked hypoechogenicity, a shape taller than it is wide, ill-defined or irregular borders, microcalcifications and hardness at elastographic evaluation. Finally, the role of US in thyroid cancer is to evaluate extension beyond the thyroid capsule and to assess nodal metastases or tumor recurrence. The main application of US in parathyroid diseases is represented by primary hyperparathyroidism. In this condition, US plays a role after biochemical diagnosis, and it should always be strictly performed for localization purposes. In both thyroidal and parathyroid diseases, US is recommended as a guide in FNA biopsies.

The thyroid and parathyroid are endocrine glands located in the neck. For their superficial position, ultrasonography (US) represents the most sensitive and cost-efficient method for their evaluation, providing accurate information about size, shape and texture. Besides these glands, an accurate ultrasonographic examination of the neck should always include the salivary glands, lymph nodes and any possible abnormal neck mass. For an optimal US evaluation, the patient should be scanned in the supine position with the neck mildly hyperextended, using a 10–14 MHz linear probe. US equipment may need to be adjusted to operate at the optimal frequency, balancing resolution and beam penetration. Deep targets should be evaluated with lower frequencies (5.0–7.5 MHz) or using convex transducers. However, the lower portions of thyroid lobes in the case of large mediastinal goiters or ectopic parathyroids may be hidden to US assessment. Despite these limits, US remains the first-line technique for the evaluation of normal and abnormal thyroid and parathyroid glands.
Thyroid Ultrasonography

Normal Anatomy
The thyroid resides in the midline of the lower neck. The gland is composed of a right and a left lobe, typically interconnected by an isthmus, lying anterolateral to the larynx and trachea at approximately the level of the second and third tracheal rings. The gland is bordered laterally by the common carotid arteries and sternocleidomastoid muscles, anterolaterally by the jugular veins, anteriorly by strap muscles and posteriorly by the longus colli muscles. The recurrent laryngeal nerve runs along the inferior thyroid artery, but it is not usually visible at US. The thyroid is attached to the larynx and trachea and, therefore, moves with the larynx during swallowing (fig. 1a).

The ultrasound appearance of a healthy thyroid parenchyma is usually homogeneous, bright and slightly hyperechoic with respect to the surrounding muscles (fig. 1b). Thyroid US also provides adjunctive information about the thyroid size, shape and texture.

Thyroid Anomalies
US is useful in detecting thyroid anomalies due to embryologic disorders, such as hemiagenesis or presence of aberrant thyroid tissue along the midline. In thyroid hemiagenesis the left lobe is the most commonly absent, with the right lobe and isthmus in the right place. The isthmus, instead, is lacking more frequently in the rarer cases of right lobe hemiagenesis. Ectopic thyroid tissue can be found anywhere along the normal path of thyroid descent, but is most commonly found at the base of the tongue (lingual thyroid). Aberrant thymic and parathyroid tissues within the thyroid gland, although extremely rare, can also be detected by US. The latter are usually hypoechoic, without significant internal vascularity on US and can easily be mistaken for thyroid nodules. Finally, US is helpful in evaluating thyroglossal duct cysts, which are usually medial, from brachial cysts, mostly placed more laterally in the neck.

Thyroiditis
The inflammation of the thyroid, i.e. thyroiditis, causes follicular changes in its parenchyma, resulting in the gland losing its uniform and bright ultrasonographic appearance. The various types of thyroiditis usually present specific ultrasonographic features.

Acute Thyroiditis
The thyroid gland is generally resistant to acute infection due to its high blood flow, iodine content, excellent lymphatic drainage and protective capsule. Therefore, acute suppurative thyroiditis, predominantly caused by Gram-positive aerobes, is rare. There is no gender predisposition and the majority of patients have an underlying thyroid disorder, such as goiter, chronic thyroiditis or a history of di-
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Rect thyroid trauma. The clinical presentation varies depending on the route of spread, type of organism and the immunocompetence of the host, but there is typically a warm, firm mass in the anterior neck that is mobile with swallowing and painful to palpation. There may be fever, dysphagia, dysphonia, hoarseness and palpable cervical adenopathy. On US imaging, the thyroid gland may be regionally or diffusely edematous. US usually demonstrates a gland with diffusely decreased echogenicity, sometimes bearing a focal abscess [1]. Abscesses are ill-defined hypoechoic, heterogeneous masses with internal debris and bright echoes from gas (fig. 2). In this context, US may also be useful in providing guidance for diagnostic or therapeutic aspiration.

Subacute Thyroiditis
Subacute granulomatous de Quervain thyroiditis is a transient, self-limited, inflammatory disorder of the thyroid gland of viral origin, representing the most common cause of a painful thyroid mass. It presents with rapid onset of thyroid tenderness, neck pain, generalized malaise, low-grade fever and occasional dysphagia, often with a history of preceding viral upper respiratory tract infection. One or both thyroid lobes may be involved and the gland may be enlarged [2]. The typical sonographic findings are focal patchy areas of marked hypoechogenicity, which may elongate along the long-axis of the gland. They may be unilateral, bilateral or migrate over time. The involved parenchyma may appear quite hypoechoic on US, with ill-defined margins, sometimes mimicking carcinoma (fig. 3). Ultrasonographic follow-up and possibly fine-needle aspiration (FNA) biopsy may be necessary to achieve the proper diagnosis.

Tuberculous Thyroiditis
Tuberculosis involving the thyroid gland is extremely rare in developed countries. Although different ultrasonographic patterns have been described, the most common clinical presentation is a solitary thyroid mass that may be visible on US as a round heterogeneously hypoechoic nodule or as an anechoic lesion (abscess) with internal echoes and ill-defined irregular borders [3]. Inflammatory changes usually produce obscuration of the surrounding tissues and fat planes.

Hashimoto’s Thyroiditis
Hashimoto’s lymphocytic thyroiditis (HT) is the most common cause of hypothyroidism in developed countries (prevalence 1–1.5 cases/1,000 people). It occurs predominantly in women (F:M = 20:1) and in patients with other autoimmune disorders. It is characterized by autoimmunity to thyroid antigens causing lymphocytic infiltration and fibrosis, sometimes resulting in glandular enlargement. In the early stages of the disease, the patient may be euthyroid, but as thyroid parenchyma becomes increasingly replaced by fibrous tissue, hypothyroidism ensues. Both benign and malignant nodules, including lymphoma, may be present in this setting.
The sonographic appearance of HT varies depending on the length and severity of the disease. Generally, thyroid echogenicity decreases as lymphocyte infiltration progresses, approaching and sometimes exceeding that of the surrounding strap muscles. With mild disease the gland may appear normal or slightly decreased in size, irregular and only mildly hypoechoic. With more advanced disease the gland may be enlarged and diffusely heterogeneous, but predominantly hypoechoic (online suppl. video 1; for all online suppl. material, see www.karger.com/doi/10.1159/000442273). The parenchyma may have an irregular echotexture, with poorly defined hypoechoic regions separated by fibrous strands simulating a multinodular goiter (fig. 4). When treated with levothyroxine, in the late stages, the gland may be very small, heterogeneous and hypoechoic.

In summary, reflecting the histopathologic features and the dynamic nature of chronic inflammatory disease, a variety of ultrasonographic patterns can be observed in HT: (a) hypoechoic and heterogeneous, in cases of mild and diffuse lymphocytic infiltration; (b) pseudomicronodular, in cases of more discrete areas of lymphocytic infiltration, forming localized hypoechoic pseudonodules (usually subcentimetric) and with the same appearance, which may vary over time – this pattern is also called ‘Swiss cheese’ or ‘honeycomb’ if very little fibrotic parenchyma separates the hypoechoic pseudonodules; (c) pseudomacronodular, when the pseudonodules are larger; (d) markedly hypoechoic when the ultrasonographic thyroid appearance is homogeneous and profoundly hypoechoic (usually in cases of the parenchyma completely replaced by lymphocytes); (e) fibrous when the fibrosis development generates hyperechoic bands separating the typical hypoechoic tissue; (f) hyperechoic and heterogeneous when, in the late stage of the disease, the fibrosis is diffuse and the thyroid may appear hyperechoic, and (g) speckled (very rare) with numerous punctate densities scattered throughout the parenchyma, often challenging the differential diagnosis with diffuse sclerosing papillary carcinoma [4, 5].

The vascularity of HT is variable, ranging from avascular to hypervascular. The possibility of malignancy in thyroiditis should be considered in case of atypical large pseudonodules, especially if calcifications, infiltrative margins or cervical lymphadenopathy are present.

Enlarged lymph nodes with reactivity features are almost invariably present in HT. The prominent nodes are in the paratracheal and pretracheal space (level VI), and near the isthmus. Lymph nodes in level VI tend to appear rounded, with a variable presence of a hilum.