Ultrasound Evaluation of the Parathyroid Glands

Evaluación mediante ultrasonido de las glándulas paratiroides

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Summary

The main indication for the study of the parathyroid glands is the suspicion of masses and specifically the suspicion of adenomas, which are the most frequent pathology. Among the different diagnostic modalities available, the most sensitive for detection are ultrasound and Sestamibi scintigraphy, which together achieve the highest specificity for diagnosis. Ultrasound evaluation of the parathyroid glands has traditionally been considered complex and operator dependent, but with the new high resolution technologies it is much simpler and we are obliged to identify them routinely, whether normal or pathological. In the present work, a review is made on the normal anatomy, exploration techniques and normal and abnormal findings in parathyroid ultrasound to perform a simple and practical approach to daily practice.

Resumen

La principal indicación para el estudio de las glándulas paratiroides son las masas y, específicamente, la sospecha de adenomas, que son la patología más frecuente. Entre las diferentes modalidades diagnósticas disponibles, las de mayor sensibilidad para su detección son el ultrasonido y la gammagrafía con sestamibi, que en conjunto alcanzan la mayor especificidad para el diagnóstico. La evaluación mediante ultrasonido de las glándulas paratiroides tradicionalmente se ha considerado compleja y operador-dependiente; sin embargo, con las nuevas tecnologías de alta resolución es mucho más sencilla y nos obligamos a identificarlas en forma rutinaria, sean normales o patológicas. En este trabajo se hace una revisión sobre la anatomía normal, las técnicas de exploración y los hallazgos normales y anormales en ultrasonido de paratiroides para realizar un abordaje sencillo en la práctica diaria.

1. Introduction

The main indication for the study of the parathyroid glands is the suspicion of masses and specifically the suspicion of adenomas, which are the most frequent pathology. Ultrasound has always been one of the most used modalities for the evaluation of these patients because, in addition to being a widely available, inexpensive tool that does not involve ionizing radiation, it has a high sensitivity to detect lesions, between 74 and 80%

However, the method of choice to diagnose adenomas is scintigraphy with sestamibi, which has greater sensitivity (up to 87%) and specificity (of 92%) and allows functional evaluation in addition to anatomical assessment, which decreases the false negatives (1, 2). These patients have also been evaluated with tomography (CT) and magnetic resonance imaging (MRI), but these modalities are more expensive and much less sensitive.

The sensitivity of all modalities is closely related to the size of the lesion. Despite this, multiple studies have shown that when a parathyroid adenoma is suspected, the combination of ultrasound and scintigraphy is more sensitive (74% -95%) than any other isolated modality (1,3).

2. Anatomy and physiology

The vast majority of people (80%) have four parathyroid glands: two superior and two inferior. However, 3 to 4% of people may have less than four and 13 to 25% may have supernumerary glands (4).

The two superior glands originate from the fourth branchial arch in conjunction with the thyroid lobes. They descend in the neck in an inferior and posterior direction behind the recurrent laryngeal nerve, until reaching its position, which is more frequent (up to 90% of the cases) immediately behind the upper portion of the superior thyroid lobes, near the cricothyroid junction. However, they may have a different location in the remaining percentage of patients, more infe-

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rior to the middle portion of the thyroid lobes (4%) or adjacent to the more superior aspect of the thyroid (3%). Much less frequent, they are found in the retropharyngeal region (1%), retroesophageal region (1%) or inside the thyroid gland (0.2%) (4,5). The two lower glands originate from the third branchial arch in conjunction with the thymus. They descend in the neck inferiorly and anteriorly in front of the recurrent laryngeal nerve and may have a more variable location than the superior ones. 69% are found in the posterior or lateral aspect of the lower poles of the thyroid lobes. However, due to their common origin with the thymus, it is common (up to 26%) to find them adjacent to the cervical portion of the same or even inside (2%), and less frequently in the superior mediastinum. Very rarely they can not descend and be next to the superior glands (4,5).

The average normal size of each gland is 5 × 3 × 1 mm, weighing 40 to 50 milligrams. They are irrigated by branches of the inferior thyroid artery and the venous drainage is done by means of tributaries of the inferior thyroid veins. The lymphatic drainage is directed to deep and paratracheal cervical ganglia and its innervation is given by the cervical sympathetic plexuses (6).

The parathyroid glands are responsible for the metabolism of calcium and its homeostasis, an action that is achieved through the production of parathyroid hormone or parathyroid hormone, when serum calcium levels fall. Paratohormone production helps to restore serum calcium levels through various mechanisms. Renal calcium absorption is activated and phosphate reabsorption decreases; in the bone system it stimulates the activity of the osteoclasts so that there is a greater release of calcium; and promotes the synthesis of vitamin D, which generates the absorption of calcium in the gastrointestinal tract (5).

3. Ultrasound evaluation

3.1 Indications

The guidelines of the American Institute of Ultrasound in Medicine (AIUM for its acronym in English) published in 2013 and developed jointly by the American College of Radiology, the Society of Pediatric Radiology and the Society of Radiologists in Ultrasound, defines the following indications of ultrasound of parathyroid glands (7):

- Complementary evaluation of incidental findings detected in other modalities.
- Patients with primary hyperparathyroidism (mainly for the presurgical location of lesions).
- Follow-up in operated patients.
- Evaluation of relapse in operated patients

3.2 Technical aspects

The patient should be in supine position with the neck hyperextended, for which it can help to put a pillow under the shoulders (Figure 1).

A linear transducer should be used with the highest possible frequency available, minimum 12 or 15 MHZ, to obtain the best images. In obese patients or with very wide necks, it is required to use transducers of 5 MHZ, but since the resolution is very low the study loses sensitivity.

Initially, parameters in mode B should be optimized: adjust the gains, center the focal point in the deep region to the thyroid, activate harmonics, and in general any other tool to obtain the best possible image. The exploration begins in the longitudinal plane, making a careful sweep from the common carotid artery to the paratracheal midline and in the opposite direction. Subsequently, a sweep should be performed in the transverse plane from the angle of the jaw to the thoracic narrow and vice-versa, bilaterally (4) (Figures 2 and 3).

Because of their size, they are sometimes not easy to identify. It is useful to make progressive compression against the trachea and ask the patient to turn the head towards the contralateral side raising the chin, in this way the pressure between the trachea and the esophagus increases and the glands move laterally becoming visible; The patient may also be asked to pass saliva.

3.3 Normal findings

Traditionally it has been said that under normal conditions it is more frequent not to identify them, because in addition to their small size, they have the same echogenicity of the thyroid or are very posterior to it, so they are difficult to scan. However, with the new high-resolution technologies we force ourselves to identify them routinely, whether normal or pathological, a situation in which they are detected more easily. Its normal eclipse is similar to that of the thyroid gland or slightly hypoechoic to it; However, when there is a decrease in the echogenicity of the thyroid gland due to some type of pathology, they can be seen to be echogenic (Figures 4 and 5).

In case of having any finding, the morphology, size and always the behavior of the lesion should be described in the Doppler assessment, because as it will be described later, it is a very useful tool for the differential diagnosis. Additionally, the complete evaluation of the thyroid gland should always be included.

4. Primary hyperparathyroidism

It is a clinical condition in which the parathyroid function is increased and serum calcium levels rise abnormally. It manifests with symptoms such as fatigue, hypertension, bone pain, muscle weakness and an altered state of consciousness to varying degrees. It prevails in women between 50 and 70 years old, with an incidence of 1/500 women and 1/2000 men (8).

In the vast majority of cases (89%), the increase in parathyroid function is secondary to a single hyperfunctioning adenoma that is usually sporadic. However, there are other causes, such as hyperplasia of the glands (6%) more frequent in patients with multiple endocrine neoplasia syndrome (MEN) type I and II, the presence of more than one adenoma (4%) or a parathyroid carcinoma (<2%) (9).

The diagnosis is mainly clinical and is made by the symptoms in a patient with altered laboratory tests (hypercalcemia, hypophosphatemia and abnormal elevation of the paratohormone, among others). The images, as mentioned, are mainly indicated for the presurgical location of the lesion that produces the picture, which in 89% of the cases corresponds to an adenoma (3).

Figure 1. Optimal position of the patient with the hyperextended neck for parathyroid exploration.

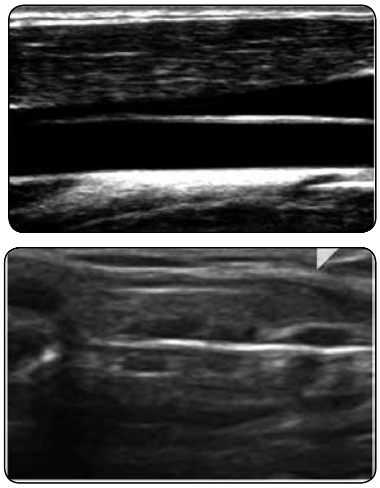
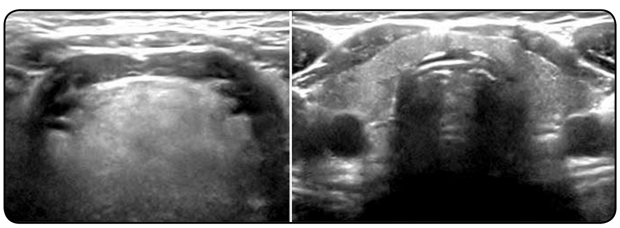


Figure 2. Sweep in the longitudinal plane.



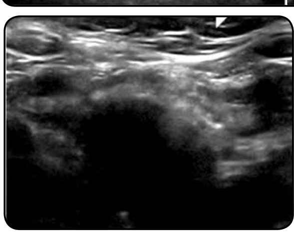


Figure 3. Sweep in the transverse plane.

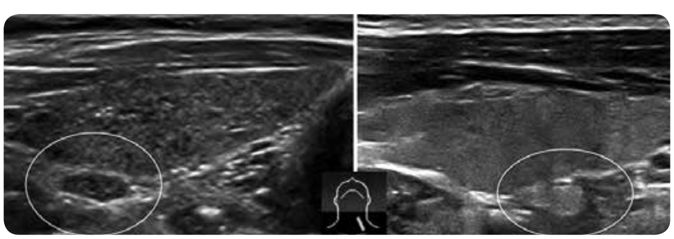


Figure 4. Normal appearance of the parathyroid glands in two different patients. They are located in the posterior aspect of the thyroid gland and separated from it by a slightly echogenic capsule. They are oval structures, well defined, and have the same echogenicity as the thyroid.

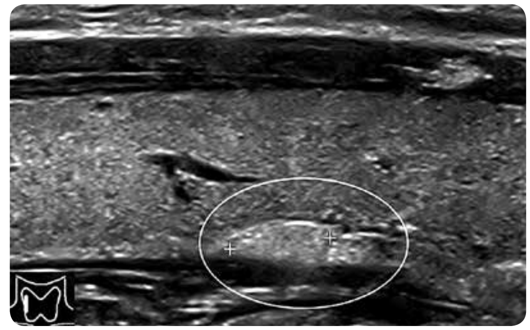


Figure 5. Apparently echogenic parathyroid gland with respect to thyroid tissue, in a patient with hypothyroidism.

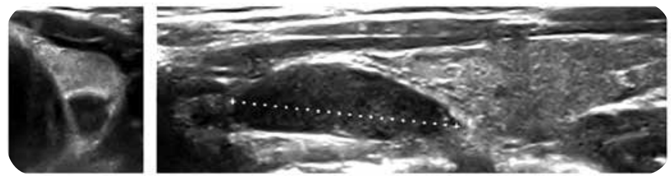


Figure 6. Adjacent to the lower pole of the left thyroid lobe, a solid, oval, circumscribed, hypoechoic lesion with respect to thyroid tissue, compatible with parathyroid adenoma is identified.

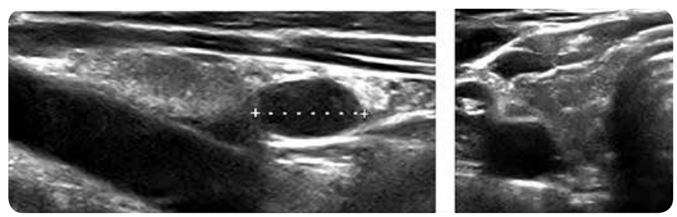


Figure 7. Adjacent to the lower pole of the right thyroid lobe, a solid lesion rounded, circumscribed, hypoechoic with respect to the thyroid tissue compatible with a parathyroid adenoma is identified.

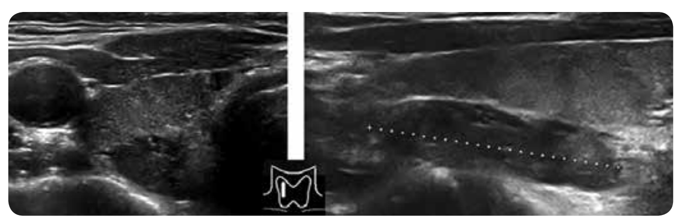


Figure 8. Adjacent to the superior pole of the right thyroid lobe, solid oval lesion, bilobed, hypoechoic with respect to the thyroid tissue compatible with parathyroid adenoma is identified.

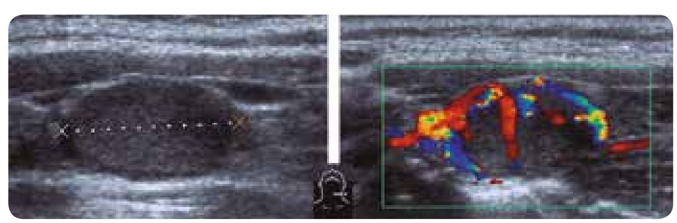


Figure 9. Parathyroid adenoma in color Doppler assessment. A feeding artery is identified, a branch of the inferior thyroid artery that enters the adenoma through one of its poles and is distributed towards the periphery (pattern in "vascular arch").

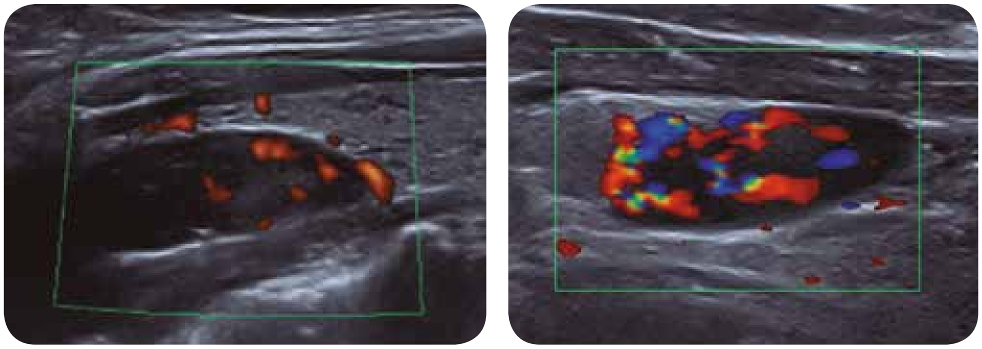


Figure 10. Color Doppler ultrasound of a patient with right parathyroid adenoma. The typical vascularization of these lesions (vascular arch pattern) is demonstrated.

Figure 11. Color Doppler ultrasound of a patient with parathyroid adenoma: the vascularization is predominantly peripheral, in “arch”.

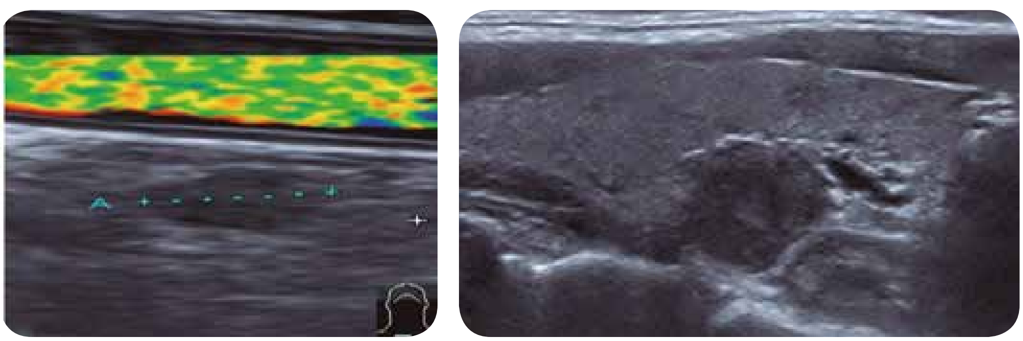


Figure 12. Ectopic parathyroid adenomas. a) Paracarid parathyroid adenoma, b) intrathyroidal parathyroid adenoma, both confirmed by pathology.

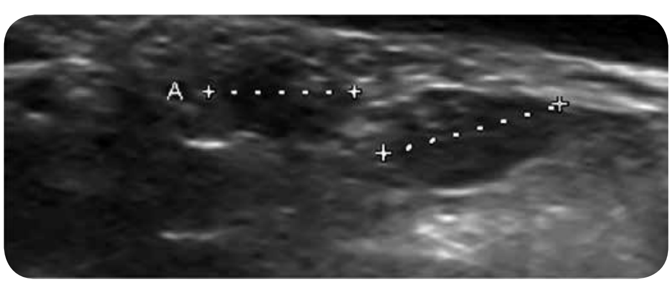


Figure 13. Two nodular lesions, solid, oval, hypoechoic and homogeneous behind the left thyroid lobe. They correspond to multiple adenomas.

Figure 14. Nodular, solid, hypoechoic image with lobular contours behind the left thyroid lobe. Parathyroid carcinoma was confirmed by pathology.

4.1 Adenoma

In ultrasound, adenomas usually have a typical appearance, oval or bilobed, well circumscribed, solid, homogeneous and hypoechoic with respect to normal thyroid tissue. They are hypoechoic due to their high cellularity and their low content of fatty tissue, which is the characteristic that offers the greatest sensitivity for their detection (Figures 6, 7 and 8).

In very rare cases, cystic changes or internal calcifications can be seen, and much less frequently, echogenic ones can appear due to a higher fat content, in which case they are known as lipoadenomas (10,11).

The evaluation with color Doppler is fundamental when an adenoma is suspected, because typically it is possible to detect a feeding artery, branch of the inferior thyroid artery, that enters the adenoma by one of its poles and distributes towards the periphery; This pattern, which is known as the "vascular arch", helps to differentiate it from lymph nodes or tumor lesions, whose vascularization would be more central (Figures 9, 10, and 11). Confirmation of diagnosis is made by combining ultrasound with parathyroid scintigraphy (12).

In symptomatic patients in whom adenomas are not easily identified, it is important to take into account atypical or ectopic locations, such as retrotracheal, mediastinal, intrathyroid, and paracarotid. The appearance will be the same, but due to its anomalous location they can easily be confused with other pathologies such as abnormal lymph nodes or intrathyroid lesions (13) (Figure 12).

4.2 Parathyroid hyperplasia and multiple adenomas

These are much less frequent lesions and more difficult to identify by ultrasound; A very variable sensitivity of 44 to 76% is found for its detection. Together they are known as multiple gland disease and the differentiation between them is solely histopathological. The echographic findings are the same as those of a typical adenoma, but what differentiates them is that in hyperplasia or multiple adenomas, there is a compromise of two or more glands, and even of four (8) (Figure 13).

4.3 Parathyroid carcinoma

It is a very rare pathology and the differentiation by ultrasound of an adenoma is difficult. Several reports describe some suggestive, but not conclusive, characteristics of this condition, which include: echogenicity lower than that of the adenoma, heterogeneous echogenicity with solid and cystic component, size greater than 2 cm, lobulated or poorly defined margins, thick capsule, invasion to adjacent tissues or associated suspected adenomegalies. However, the final diagnosis is histopathological (1) (Figure 14).

5. Treatment

In selected patients, hypocalcemic agents, such as calcitonin and bisphosphonates, can be used for treatment. However, the only definitive treatment is surgical resection.

The follow-up in these patients is done with laboratory tests and the images are reserved for cases in which persistence or recurrence of the disease is suspected. There is talk of persistent hyperparathyroidism when serum calcium does not reach normal values at any time after surgery, and its main cause is an unidentified ectopic adenoma. There is talk of recurrence when hypercalcemia appears after at least six months of having normal serum calcium, a condition that in most cases results from the growth of some remnant of parathyroid tissue.

6. Conclusion

Parathyroid ultrasound represents a widely available modality with great sensitivity for the detection of parathyroid pathology. It is essential to know the normal anatomy and its possible variants, the technical parameters, the normal appearance and the abnormal findings, for its correct interpretation. Additionally, possible sources of error for discrimination must be taken into account. The most frequent false positives are given by cervical lymph nodes, prominent vascular structures, the esophagus, the long neck muscle and thyroid nodules; and frequent false negatives include very small adenomas, multinodular goiter or ectopic adenoma localization. For this reason, it should be remembered that the combination of ultrasound with scintigraphy represents the best option for the assessment of these patients, since overall they surpass the other individual modalities in terms of sensitivity and specificity.

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