Thyroid and Parathyroid Gland
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THYROID AND PARATHYROID GLANDS

1) Other Names:

- None

2) Definition/Location:

Thyroid

- The thyroid is located in the anterior neck at the level of the thyroid cartilage (Hagen-Ansert, p.515, 2/2/1).
- It is an endocrine gland (one of the ductless glands, which release their secretion into the blood) consisting of two lateral lobes and a connecting portion called the isthmus (Curry-Tempkin, p.367, 2/1/1), (Curry-Tempkin, p.368, Fig. 20-1).
- Maintains body metabolism (Tempkin, p.314 "Physiology").
- The isthmus unites the lower third of the lobes at the level of the second, third, and fourth tracheal rings (Curry-Tempkin, p.368, 2/1/2), (Curry-Tempkin, p.368, Fig. 20-1).
- It is covered by two thin layers of connective tissue. The first layer is pretracheal fascia, or false thyroid capsule, which surrounds the gland. The second layer is the true thyroid capsule, adherent to the gland surface. Thyroid parenchyma is composed of follicles (glandular epithelium and colloid), connective tissue, stroma, blood vessels, nerves, and lymphatics (Curry Tempkin, p.370, 1/2/2).
- The thyroid gland secretes three significant hormones: thyroxine (T_4), triiodothyronine (T_3), and calcitonin, which affect body metabolism, growth, and development (Curry-Tempkin, p.367, 2/1/2).
- The thyroid straddles the trachea anteriorly, whereas the paired lobes extend on either side of the trachea, bounded laterally by the carotid arteries and jugular veins (Hagen-Ansert, p.516, Fig. 18-1). When present, the pyramidal lobe arises from the isthmus and tapers superiorly just anterior to the thyroid cartilage (Hagen-Ansert, p.515, 2/2/4).
- Along the anterior surface of the thyroid gland lie the strap muscles, including the sternothyroid, omohyoid, sternohyoid, and sternocleidomastoid muscles (Hagen-Ansert, p.515, 2/4/1), (Hagen-Ansert, p.516, Fig. 18-2).
- Posterolateral anatomy includes the carotid sheath with the common carotid artery, internal jugular vein, and vagus nerve. The longus colli muscle is posterior and lateral to each thyroid lobe and appears as a hypoechoic triangular structure adjacent to the cervical vertebrae (Hagen-Ansert, p.516, 1/2/1), (Hagen-Ansert, p.516, Fig. 18-2).

- Medial anatomy consists of the larynx, trachea, inferior constrictor of the pharynx, and esophagus. The esophagus, primarily a midline structure, may be found to the left of the trachea (Hagen-Ansert, p.516, Fig. 18-2). It is identified by the target appearance in the transverse plane and by its peristaltic movements when the patient swallows. The posterior border of each thyroid lobe is related to the superior and inferior parathyroid glands and the anastomosis between the superior and inferior thyroid branches (Hagen-Ansert, p.516, 1/2/1).
- Blood supply to the thyroid is by four arteries. Two superior thyroid arteries arise from the external carotids and descend to the upper poles. Two inferior thyroid arteries come from the thyrocervical trunk of the subclavian artery and ascend to the lower poles (Hagen-Ansert, p.516, 2/1/1).

Parathyroid

- The four parathyroid glands lie between the posterior aspect of the thyroid gland and the longus colli muscle (Tempkin, p.313 "Location").
- The four parathyroid glands are paired. Two lie posterior to each superior pole of the thyroid, and the other two lie posterior to the inferior pole (Hagen-Ansert, p.526, 1/2/4), (Hagen-Ansert, p.516, Fig. 18-1).
- They are typically symmetric in position. The two superior glands are situated slightly more medial than the two inferior glands (Tempkin, p.313 "Location").
- Superior parathyroid glands are situated more posteriorly and medially than inferior parathyroid glands. They normally lie at the thyroids mid to upper portion (Curry-Tempkin, p.375, 2/3/2).
- Inferior parathyroid glands are situated more anteriorly than superior parathyroid glands. They are found on the posterior lateral surface of the thyroid gland, anterior and medial to the recurrent laryngeal nerve and inferior thyroid artery. Inferior parathyroid glands may also be imbedded within the thyroid tissue (Curry-Tempkin, p.376, 1/1/3).
- Parathyroid glands are composed of masses of chief cells, with some wasserhelle (water-clear) and oxyphil cells arranged in a columnar fashion. The color of parathyroid glands varies from light yellow in older patients to a reddish or light brown in young patients, depending on the amount of fat within the gland (Curry-Tempkin, p.376, 1/4/1).
- The parathyroid glands secrete parathormone (PTH) which controls the calcium level in the blood (Tempkin, p.314 "Physiology").

3) Ultrasound Appearance:

Thyroid

- The normal thyroid gland is uniformly echogenic, with medium-to high-level echoes similar to those of the liver and testes. It is more echogenic than the contiguous muscular structures and vasculature (Curry-Tempkin, p.373, Fig. 20-9). Branches of the inferior and superior thyroid arteries and veins appear as anechoic tubular structures with bright thin walls (Curry-Tempkin, p.372, 1/2/1), (Curry-Tempkin, p.372, Fig. 20-7), (Hagen-Ansert, p. 519, Fig. 18-4).

- On transverse images, the CCA and IJV are seen as circular area with hyperechoic walls, adjacent to the lateral border of the thyroid gland. The neck muscles (infrahyoid, sternocleidomastoid, and longus colli) are hypoechoic relative to the thyroid gland. The LCM is triangularly shaped (Curry-Tempkin, p.372, 2/1/1).
- The esophagus is visualized slightly to the left of midline, adjacent to the trachea, and appears as a circular hypoechoic structure with an echogenic center representing mucosa (Curry-Tempkin, p.372, 2/1/4).
- The vagus nerve is visualized as a hypoechoic dot lateral to the thyroid lobe, usually located between the carotid artery and jugular vein (Curry-Tempkin, p.372, 2/1/5).
- The recurrent laryngeal nerve is a circular hypoechoic structure with an echogenic rim located between the esophagus, trachea, and posterior thyroid lobe (Curry-Tempkin, p.372, 2/1/6), (Curry-Tempkin, p.372-373, Fig. 20-8, 20-9).

Parathyroid

- Normal parathyroid glands are not usually seen by ultrasound but occasionally a single gland may be identified as a flat hypoechoic structure posterior to the thyroid and anterior to the longus colli muscle (Tempkin, p. 314 "Sonographic Appearance").
- Branches of intrathyroidal veins and arteries appear as 1-2 mm anechoic tubular structures (Tempkin, p.314 "Sonographic Appearance").

4) Normal Size Range(s):

- The size and shape of the thyroid gland varies with gender, age, and body surface area, with females having a slightly larger gland than males. The lobes are normally equal in size (Hagen-Ansert, p. 515, 2/3/1).
- The normal adult thyroid measures 4-6 cm in length, 1.3-2.0 cm in diameter, and 1.5-2.0 cm in width. The isthmus is the smallest part of the gland and has a 2-6 mm diameter (Hagen-Ansert, p. 515, 2/3/5).
- For children, the gland measures 2.0-3.0 cm in length, 0.2-1.5 cm in diameter, and 1.0-1.5 cm in width (Curry Tempkin, p. 370, 1/1/1).
- The shape of the parathyroid glands varies. They are generally oval, bean shaped, or spherical (83%), or sometimes elongated, bilobulated, or multilobulated (Curry-Tempkin, p. 376, 1/5/1).
- The normal parathyroid gland should measure approximately 5-7 mm in length, 3-4 mm in width, and 1-2 mm in thickness (Curry-Tempkin, p. 376, 1/3/1).

5) Pertinent Lab Data:

The Thyroid Gland (Curry-Tempkin, p. 375, "Laboratory Values")

- Resin T3 Uptake (RT3U) (Specimen S): 25-35%; an increase of T3 into the resin indicates hyperthyroidism, a decrease in the resin indicates hypothyroidism,
- Thyroid Stimulating Hormone (Specimen S): 5-10 u U/ml.

- Thyroxine (T4) (Specimen S): 4.5-13 ug/dl. Increases in T4 are associated with hyperthyroidism; decreases in T4 represent hypothyroidism.
- Triiodothyronine: 75-195 ug/dl. Pregnancy and oral contraceptives tend to increase values.
- Euthyroid is when the thyroid is producing the right amount of thyroid hormone, it is considered to be normal. Hypothyroidism is the undersecretion of thyroid hormones. Hyperthyroidism is the oversecretion of thyroid hormones (Hagen-Ansert, p. 517, 1/4/1).

The Parathyroid Gland: (Curry-Tempkin, p. 382, "Laboratory Values")

- Alkaline Phosphorus (Specimen S): 1.5-4.5 Bodansky units/dl; 0.8-2.9 BLB units.
- Calcium (Specimen S): Adult 8.4-10.2 mg/dl; child 8.8-10.7 mg/dl.
- Chloride (Cl): 98-106 mmol/L (Specimen S); 110-250 mmol/L (CSF).
- Phosphorus (Specimen S): 2.7-4.5 mg/dl.
- Protein (Total): 6.5-8.3 g/dl (Specimen S); 0.5% of plasma (CSF).
- Uric Acid (Specimen S): Male 3.5-7.2 mg/dl; female 2.6-6.0 mg/dl.\
- When the serum calcium level decreases, the parathyroid glands are stimulated to release PTH. When the serum calcium level increases, parathyroid activity decreases. PTH acts on bone, kidney, and intestine to enhance calcium absorption. Patients with unexplained hypercalcemia detected on routine blood chemistry screening are the most common referrals for parathyroid echography (Hagen-Ansert, p. 526, 1/4/4).

6) Common Pathologies:

Thyroid

- **Nontoxic Simple Goiter-** occurs as a diffuse thyroid enlargement not resulting from a neoplasm or inflammation. The goiter is formed when the gland is unable to provide an adequate supply of thyroid hormone. This may be the result of iodine shortage or malfunction of the gland itself. Sonographic findings include enlargement of the thyroid gland, sometimes smooth, sometimes nodular. One side may enlarge more than the other, and possibly compression of the surrounding structures (Hagen-Ansert, p. 520, 1/4/1), (Hagen-Ansert, p. 522, Fig. 18-11).
- **Toxic Multinodular Goiter-** also known as adenomatous hyperplasia, is one of the most common forms of thyroid disease. Approximately 90% of nodular thyroid disease is caused by hyperplasia of the gland. It occurs in up to 5% of any population. Sonographic findings include an enlarged, inhomogeneous gland. As the disease progresses, areas of focal scarring and ischemia, as well as necrosis and cyst formation may appear within the gland (Hagen-Ansert, p. 520, 2/3/1), (p. 521, Fig. 18-9, 18-10).
- **Graves' Disease-** occurs more frequently in women over 30 years of age and is related to an autoimmune disorder. It is characterized by thyrotoxicosis and is the most frequent cause of hyperthyroidism. On ultrasound examination, the gland appears hypoechoic with diffuse enlargement without palpable nodules. The overactivity of Graves' disease is manifested

sonographically by increased vascularity on color Doppler imaging leading to the term “thyroid inferno” (Hagen-Ansert, p. 521, 2/2/1), (p. 522, Fig. 18-12, 18-13).

- **Thyroiditis-** swelling and tenderness of the thyroid. It is caused by infection or can be related to autoimmune abnormalities. Sonographic findings include a coarse and homogenous texture. The gland may appear hypoechoic compared with a normal thyroid texture. Discrete thyroid nodules are less commonly seen. Color Doppler shows increased vascularity (Hagen-Ansert, p. 521, 2/6/1), (p. 523, Fig. 18-14).
- **Benign Lesions-** a discrete nodule of the thyroid gland is the most common reason for an ultrasound examination. Nodular thyroid disease is frequently encountered in the adult population, with up to 7% found to have a benign nodule, with women more affected than men (Hagen-Ansert, p. 522, 2/4/1).
- **Cysts-** are thought to represent cystic degeneration of a follicular adenoma. Sonographic findings include purely anechoic areas result from serous or colloid fluid, echogenic fluid, or moving fluid; fluid levels correspond to hemorrhage. Approximately 20% of solitary nodules are cystic. They also have sharp, well-defined walls and distal acoustic enhancement (Hagen-Ansert, p. 522, 1/5/1), (p. 523, Fig. 18-15).
- **Adenoma-** a benign thyroid neoplasm characterized by complete fibrous encapsulation. They represent 5-10% of all nodular disease of the thyroid and are seven times more common in females than in males. Adenomas are homogeneous with variable size. Usually the lesion is solitary with areas of hemorrhage or necrosis. The adenoma is slow growing unless hemorrhage occurs, which causes sudden and painful enlargement (Hagen-Ansert, p. 523, 1/2/1), (Hagen-Ansert, p. 521, Fig. 18-7), (Hagen-Ansert, p. 524, Fig. 18-17).
- **Malignant Lesions-** Carcinoma of the thyroid is rare. The ultrasound appearance of thyroid cancer is highly variable. The neoplasm can be of any size, single or multiple, and can appear as a solid, partially cystic, or largely cystic mass. Thyroid cancer is usually hypoechoic relative to the normal thyroid. Calcifications are present in 50-80% of all types of thyroid carcinoma (Hagen-Ansert, p. 523, 2/3/1).
- **Papillary Carcinoma-** the most common of the thyroid malignancies is called papillary carcinoma and is the predominant cause of thyroid cancer in children. The major route of spread is through the lymphatics to the nearby cervical lymph nodes. Sonographic findings include hypoechogenicity in 90% of cases, microcalcifications that appear as tiny, punctuate hyperechoic foci, and hypervascularity (Hagen-Ansert, p. 524, 1/2/1), (p.525, Fig. 18-18, 18-19).
- **Follicular Carcinoma-** is usually a solitary mass of the thyroid. This type of thyroid cancer is more aggressive than papillary cancer. Characteristic sonographic findings include an irregular, firm, nodular enlargement (Hagen-Ansert, p. 524, 1/4/1), (p. 525, Fig. 18-20).
- **Medullary Carcinoma-** accounts for 10% of thyroid cancers. It presents as a hard, bulky mass that causes enlargement of a small portion of the gland and can involve the entire gland. Thyroid lesions appear as punctuated, bright

echogenic foci within solid masses (Hagen-Ansert, p. 524, 2/2/1), (p. 525, Fig. 18-21, 18-22).

- **Anaplastic Carcinoma-** is rare and accounts for less than 10% of thyroid cancers. Usually occurs after age 50. This lesion presents as a hard, fixed mass with rapid growth. The sonographic appearance of this type of thyroid cancer is a hypoechoic mass, with invasion of surrounding muscles and vessels of the neck (Hagen-Ansert, p. 524, 2/4/1).

Parathyroid

- **Primary Hyperparathyroidism**- a state of increased function of the parathyroid glands. This is common after menopause. Characterizations include hypercalcemia, hypercalciuria, and low serum levels of phosphate. Most patients are asymptomatic at time of diagnosis. Primary hyperparathyroidism occurs when increased amounts of PTH are produced by an adenoma, primary hyperplasia, or rarely carcinoma locate din the parathyroid gland (Hagen-Ansert, p. 526, 2/3/1).
- **Secondary Hyperparathyroidism**- is a chronic hypocalcemia caused by renal failure, vitamin D deficiency (rickets), or malabsorption syndromes. These abnormalities induce PTH secretion, which leads to secondary hyperparathyroidism. All four glands are usually affected (Hagen-Ansert, p. 527, 2/2/1).
- **Primary Hyperplasia**- Of the patients with hyperparathyroidism, approximately 10% have parathyroid hyperplasia. It is a hyperfunction of all parathyroid glands with no apparent cause. Only one gland may significantly enlarge (Hagen-Ansert, p. 527, 1/1/1), (p. 526, Fig. 18-23).
- **Adenoma**- Adenoma is the most common cause of primary hyperparathyroidism (80% of all cases). A solitary adenoma may involve any of the four glands with equal frequency. Adenomas are benign and usually less than 3 mm. The most common shape is oval. Sonographic findings include hypoechoic adenomas, and the vast majority are solid. Color Doppler may show a hypervascular pattern or a peripheral vascular arc that may aid in the differentiation from hyperplastic regional lymph nodes, which have hilar flow (Hagen Ansert, p. 527, 1/3/1), (p. 527, Fig. 18-24).
- **Carcinoma**- Histologic differentiation of adenoma and carcinoma is very difficult. Metastases to regional nodes or distant organs, capsular invasion, or local recurrence must be present for cancer to be diagnosed. Most cancers of the parathyroid glands are small, irregular, and firm masses. The mass may adhere to surrounding structures (Hagen-Ansert, p. 527, 2/1/1).

7) Patient Prep:

- The patient is placed in the supine position with a pillow under both shoulders to provide a moderate hyperextension of the neck. This position allows the lower lobes of the gland to be more readily visualized with ultrasound (Hagen-Ansert, p.517, 2/3/1).
- Can also use a rolled up towel for adjustability.
- Might need to severely hyperextend athletic or obese patients.

8) **Transducer (Probe) Frequency:** (Tempkin, p. 315, "Transducer")
   - High Resolution, real-time, linear transducer. 7.5-10 MHz.
   - 5.0 MHz recommended for a very muscular or fat neck.
   - According to the transducer and machine used, a water path or standoff pad may be necessary.
   - Doppler color flow imaging (low-flow filter, scale, and optimized color gain).

9) **Protocol:** (Tempkin, p. 318-323, "Required Images")
   Thyroid:
   - In transverse, images are taken that show the inferior, mid, and superior portion of the right and left lobe. An image is also taken of the isthmus to include both the right and left lobe attachments.
   - In longitudinal, images are taken that show the medial and lateral portions of the right and left lobe.

10) **Image Reference:**
   - Curry-Tempkin, p.368, Fig. 20-1
   - Hagen-Ansert, p.516, Fig. 18-1
   - Hagen-Ansert, p.515, Fig. 18-2
   - Curry-Tempkin, p.373, Fig. 20-9
   - Curry-Tempkin, p.372, Fig. 20-7
   - Hagen-Ansert, p. 519, Fig. 18-4
   - Curry-Tempkin, p.372-373, Fig. 20-8, 20-9
   - Hagen-Ansert, p. 522, Fig. 18-11
   - Hagen-Ansert, p. 521, Fig. 18-9, 18-10
   - Hagen-Ansert, p. 522, Fig. 18-12, 18-13
   - Hagen-Ansert, p. 523, Fig. 18-14
   - Hagen-Ansert, p. 523, Fig. 18-15
   - Hagen-Ansert, p. 521, Fig. 18-7
   - Hagen-Ansert, p. 524, Fig. 18-17
   - Hagen-Ansert, p. 525, Fig. 18-18, 18-19
   - Hagen-Ansert, p. 525, Fig. 18-20
   - Hagen-Ansert, p. 525, Fig. 18-21, 18-22
   - Hagen-Ansert, p. 526, Fig. 18-23
   - Hagen-Ansert, p. 527, Fig. 18-24

11) **References:**

   - Curry, R.A. and Tempkin, B.B. (2004). Sonography: Introduction to normal structures and function (2nd ed.). St. Louis, MO: Saunders.
   - Hagan-Ansert, S.L. (2006). Textbook of diagnostic ultrasonography (6th ed.) (Vol.1). St. Louis, MO: Mosby.
   - Tempkin, B.B. (1999). Ultrasound scanning: Principles and protocols (2nd ed.). Philadelphia, PA: Saunders.