Anatomy of the Thyroid Gland

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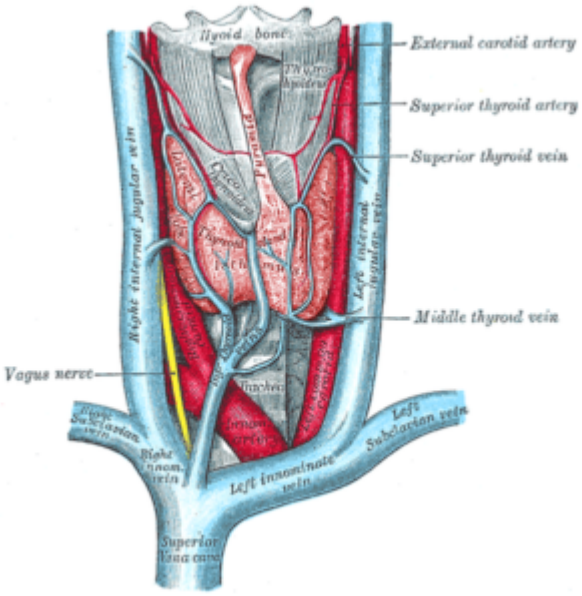
The thyroid gland is one of the largest and actively functioning endocrine glands. It is a highly vascular, brownish-red gland located in the visceral compartment of the anterior part of the neck, spanning between the C5 and T1 vertebrae.

Lobes of the Thyroid Gland

The thyroid gland is divided into **two lobes**, the left lobe and the right lobe connected by the **isthmus**. The combination of the two conical or pyramidal shaped lobes and the isthmus forms an H or butterfly-shaped structure. Each lobe is roughly 50—60 mm long, weighing around 25-30 g (this varies from person to person and male to female).



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The gland may enlarge in some normal conditions like menstruation and pregnancy. Of the neck muscles, the thyroid is covered anteriorly by the strap (or infrahyoid) muscles and by the sternocleidomastoid muscles. **The infrahyoid muscles** (**strap muscles**) are the sternohyoid, sternothyroid, thyrohyoid and omohyoid.

The gland is located within the **visceral compartment** of the neck, along with the trachea, esophagus, and pharynx. The compartment is bound by the pretracheal fascia.

Posterior to the thyroid lies the cricoid cartilage and superior tracheal rings, enclosed in a thin fibrous sheath, the capsule of the thyroid. The external layer is anteriorly continuous with the pretracheal fascia and posterolaterally continuous with the carotid sheet. The capsule extrudes into the gland itself and forms the septae that divide the thyroid tissue into microscopic lobules. In some people the isthmus of the thyroid gland is absent.

In some people, the remnants of the **thyroglossal duct** persist and form an accessory thyroid nodule or cyst of thyroid tissue. These remnants are usually found in between the isthmus and the **foramen caecum** at the base of the tongue, where the thyroid originated in the embryo. Occasionally, it becomes enlarged and is visible as a swelling in the anterior part of the neck. A lingual thyroid located at the base of the tongue may be the only thyroid tissue present in the body. An ultrasound of the neck should be done in every case prior to removal of the lingual thyroid.

Two pairs of parathyroid glands are found in close proximity to the thyroid gland. The superior parathyroids are lodged within the parenchyma of the upper parts of the right and left lobes and the inferior parathyroids are close to the inferior tips of the lobes.

Histology of the Thyroid Gland

The lobules of the thyroid gland are composed of **thyroid follicles**. These are the structural and functional unit of this gland. Each follicle is composed of simple epithelium covering a cavity filled with colloid material which contains an iodinated glycoprotein called the **iodo-thyroglobulin**. This iodo-thyroglobulin is a precursor of the **thyroid hormone**.

The size of the follicles depends on the activity of the gland. In a **hyperactive state**, the

epithelium of the follicles is in secretory phase and they are filled with colloid material. When the gland is in a **hypoactive state**, follicles are in a normal state with the normal size of follicles.

There are two types of epithelial cells:

1. Principal (or follicular) cells
2. C cells (or clear, light cells or para-follicular) cells

The function of the follicular or principal cells is to secrete the colloid containing iodo-thyroglobulin, whereas the parafollicular cells produce the hormone **calcitonin**. This hormone, in conjunction with the parathyroid hormone produced by the chief cells of the parathyroid glands, regulates calcium levels in the blood.

Strap Muscles and True and False Capsule

Strap muscles

The thyroid gland is covered by the “strap muscles” of the neck. The lateral surface of the gland is covered by the **sternothyroid muscle**. Anterior to this muscle is the **sternohyoid muscle** and the superior belly of the **omohyoid muscle**. The nerve supply of the muscles enters the muscles inferiorly coming from the ansa cervicalis. During thyroid surgery, if the strap muscles are to be transected to expose the gland, it should be done superiorly.

True and false capsule

The **pretracheal fascia**, which covers the trachea and few other structures in the neck, also encapsulates the thyroid gland. It is labeled as the false capsule or the visceral layer of the pretracheal fascia. The posteromedial aspect of the gland is attached to the side of the cricoid cartilage, first and second tracheal ring, by the posterior suspensory ligament (i.e., Berry ligament). This firm attachment of the gland to the laryngeal skeleton is responsible for the movement of the thyroid gland and related structures during swallowing.

Beneath this false capsule, the thyroid gland is covered by a thin layer of true capsule, which divides the gland into lobes and lobules through **septae formation**. Lobules are further divided into follicles, which are the main structural unit of the gland. The inner capsule is thin and sticks to the gland closely.

Blood vessels, i.e. arteries and veins along with lymphatics, also move along these septae and cross the true and false capsule to supply the gland or carry away blood loaded with thyroid hormone secretions toward the heart and the rest of the body.

Relationships of the Thyroid Gland

Relationships of the right lobe of the thyroid gland

The right lobe of the thyroid gland is related to two **parathyroid glands** lying posteriorly: a superior and an inferior parathyroid gland. Inferiorly, it is related to the **right inferior thyroid artery** and **right recurrent laryngeal nerve** and superiorly it is related to the **right superior thyroid artery** and the **right superior laryngeal nerve**. Relations of the arteries with the nerves lying superior and inferior to the gland are

important to remember when performing a **thyroidectomy**.

Relationships of the left lobe of the thyroid gland

The left lobe of the gland is related to the **left superior thyroid artery** and the **left superior laryngeal nerve**. Inferiorly, the lobe is related to the **left inferior thyroid artery** and the **recurrent laryngeal nerve**. Relations of both these arteries and the nerves should be closely observed during the thyroidectomy.

Relationships of the isthmus of the thyroid gland

The isthmus is related posteriorly to the **cricoid cartilage, and the first and second tracheal rings,** the **cricothyroid membrane** superiorly and to the **strap muscles** and the **deep cervical fascia** anteriorly and inferiorly.

Supply and Drainage System of the Thyroid Gland

Blood supply of the thyroid gland

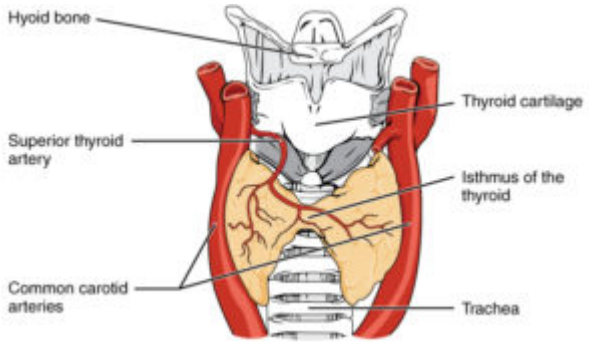

Image: "Anatomy and arterial supply of the thyroid gland – anterior view" by CFCF – Own work, License: CC BY-SA 3.0

The thyroid gland is supplied by the branches of the major vessels of the heart. Two main arteries supply the thyroid gland:

- the superior thyroid artery and
- the inferior thyroid artery.

The **superior thyroid artery** is the first branch of the **external carotid artery**, which supplies the upper part of the thyroid gland. It divides into anterior and posterior branches.

The **inferior thyroid artery** is the major branch of the **thyrocervical trunk,** a branch of the subclavian artery, and it supplies the lower half of the thyroid. It is also divided into several branches.

An additional artery present in a small number of people is known as the **thyroid ima artery**. It emerges from the **arch of the aorta** or the **brachiocephalic trunk** and supplies the isthmus and the lower part the gland.

Venous drainage of the thyroid gland

The venous drainage of the gland occurs through three major veins:

- Superior thyroid veins
- Middle thyroid veins
- Inferior thyroid veins

These veins form a **venous plexus** on the anterior surface of the thyroid gland. The superior thyroid veins accompany the superior thyroid artery and empty in the **internal jugular vein** or the **facial vein**. They collect deoxygenated blood from the upper part of the gland.

The middle thyroid vein is relatively short. It collects deoxygenated blood from the middle part of the thyroid lobes and empties into the internal jugular vein.

Inferior thyroid veins drain into the **brachiocephalic veins**. They collect deoxygenated blood from the lower part of the gland through the venous plexus.

Nerve supply of the thyroid gland

The **autonomic nervous system** supplies the thyroid gland via the **Vagus** and **superior, middle and inferior cervical sympathetic ganglia**. Autonomic regulation of thyroid hormone secretion is not clearly understood.

The vagal and sympathetic fibers to the gland follow the course of blood vessels. A **peri-arterial plexus** is formed around the gland, which supplies the gland and penetrates the gland through the septae. Nerves also enter the gland along with these blood vessels. These nerve fibers produce **vasoconstriction** which decreases blood perfusion to the gland, affecting gland secretion. Hormonal secretion is controlled by the **thyroid secreting hormone,** produced in the **pituitary gland**.

Lymphatic drainage of the thyroid gland

The thyroid gland is rich in lymphatic vessels. There is an extensive system of lymphatic drainage which flows in multiple directions. All the lymphatic vessels first drain in the **peri-glandular and pre-laryngeal lymph nodes**, then to the **pre-tracheal and para-tracheal lymph nodes** present along the **recurrent laryngeal nerve (RLN)**, and finally to **mediastinal lymph nodes**.

Relations of the Recurrent Laryngeal Nerve

The inferior thyroid artery is closely associated with the recurrent laryngeal nerve. The relationship of the recurrent laryngeal nerve and the inferior thyroid artery is highly variable: the nerve can lie deep to the artery seen in 40% of the cases, superficial to the artery in roughly 20% of the population, or in between the branches of the artery in 35% of the population, and be different on either side of the neck. The anatomy of the left side is similar on both sides in only 17% of the population.

Consideration of the anatomy of this nerve and its branches must be made during thyroidectomy. Preservation of all the branches of the recurrent laryngeal nerve should be ensured during thyroid surgery, as the laryngeal nerve controls the movement of the vocal cords and carry sensory information from the mucous membranes of the larynx below the lower surface of the vocal fold.

Clinical Anatomy of the Thyroid Gland

The thyroid hormone system

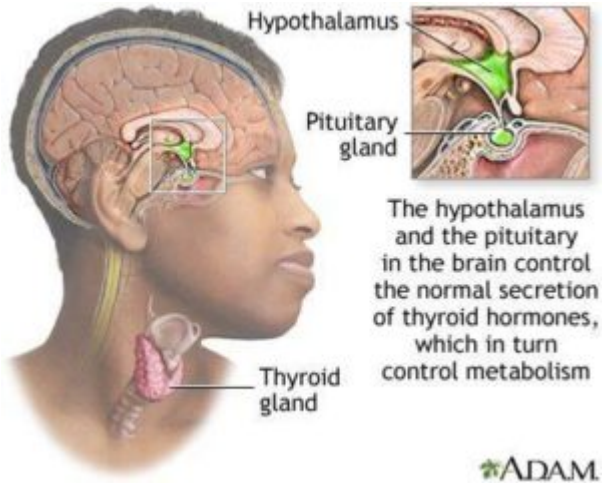

Image: "Hypothalamus, pituitary gland and thyroid gland" by Claire Moore – http://suite101.com/article/graves-disease-may-be-confused-with-other-hyperthyroid-disorders-a411522, License: Public Domain

The thyroid gland produces two hormones:

1. Thyroid hormone
2. Calcitonin

The thyroid hormone is produced in response to the thyroid-stimulating hormone from the **pituitary gland**.

T3 (tri-iodothyronine) and **T4 (tetraiodothyronine)** are the two thyroid hormones released into the blood circulation. Initially, T4 is produced in the gland and stored. On stimulation from the pituitary gland, T4 is released into the blood by the gland which is converted into T3 in the liver and other tissues. T4 is the inactive form of thyroid hormone while T3 is the active form.

Thyroid hormone increases cell **metabolism** and promotes growth and development. The following are the major functions of the thyroid hormone:

1. Promotes tissue oxygen consumption
2. Increases **catecholamine** production
3. Promotes cellular catabolic pathways and heat production
4. Promotes **glycolysis**, **glycogenolysis**, **fatty acid oxidation**, the **Kreb's cycle**, and **protein synthesis**
5. Helps regulate long bone growth and neural maturation
6. Inhibits the **glycogen synthesis**, **gluconeogenesis**, **fat deposition** into the adipose tissues

Thyroid hormone has the following effects on the body:

1. Increases heart rate
2. Increases body temperature
3. Promotes **peristalsis**
4. Increased sweating

5. Promotes the production of **adrenaline** and **noradrenaline**

Feedback system for the regulation of thyroid hormone

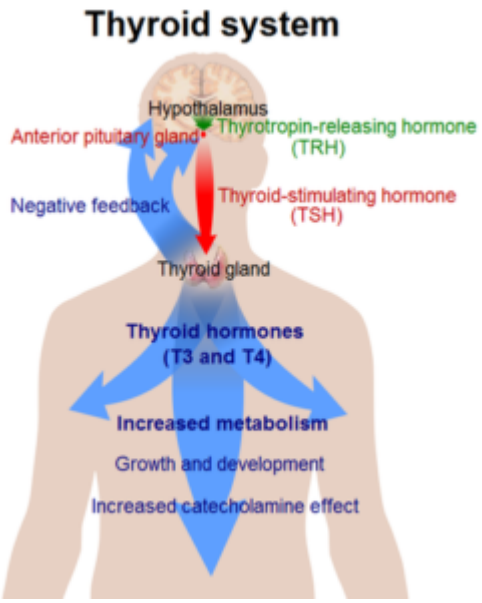

Image: "The thyroid system" by Mikael Häggström, License: Public Domain

The body feedback system assesses the levels of thyroid hormone in the blood and its need in the body and promotes the release of thyroid releasing hormone from the **hypothalamus**, which stimulates **TSH secretion** from the pituitary gland. TSH causes thyroid hormone production from the thyroid gland.

Calcitonin

Calcitonin is produced by the parafollicular cells (**C cells**) of the thyroid gland. Initially, **procalcitonin** is released, which is later converted into **procalcitonin**, then **immature calcitonin** and later into **mature calcitonin**.

Calcitonin inhibits the activity of the **osteoclasts** leading to inhibition of the **bone resorption**. Its action is on the bone, kidneys, and GI tract. It also inhibits parathyroid hormone and **vitamin D**.

Hyperactivity of the thyroid gland

Diseases or any other cause can lead the thyroid gland to swell.

Thyroid swelling can be due to a solitary nodule or multiple nodules. The nodule can be cold or hot, benign or malignant. **Thyroid cancer** is also a common occurrence.

Histology

Thyroid follicles are in a hyperactive state and are filled with colloid material surrounded by simple epithelium.

Goiter

Image: “Hyperthyroidism” by Blausen.com staff. “Blausen gallery 2014”. Wikiversity Journal of Medicine. DOI:10.15347/wjm/2014.010. ISSN 20018762. – Own work, License: CC BY 3.0

A swollen thyroid gland due to hypo- or hypersecretion of the thyroid hormone or due to inflammation is called goiter. A goiter can be of a single nodule called the **solitary nodular goiter** or more than one nodule/swellings/lumps in different parts of the gland called **multi-nodular goiter**.

Types of goiter

1. Simple goiter – enlargement of the thyroid gland in a **euthyroid** (when thyroid hormone secretion is within normal limits), in a patient without any neoplastic or inflammatory process
2. Familial goiter – occurs due to **inherited enzymatic defect** leading to the accumulation of the secretion in the gland and causing its enlargement
3. Endemic goiter – thyroid swelling which is caused by the **deficiency of iodine** among the people of a population living in areas at a great distance from the ocean, the major source of iodine.
4. Sporadic goiter – thyroid swelling in which **no defined cause** can be established.
5. Multi-nodular goiter – consists of multiple, visible or palpable, nodular enlargements. Usually, it occurs with **hyperthyroidism**, in which hyperactivity of the gland leads to multiple nodule formations.
6. Diffuse goiter – when abnormal hormone secretion of the gland leads to uniform enlargement of the gland.

Thyroidectomy

Surgical removal of the thyroid gland is called thyroidectomy.

After exposing the gland through neck surgery with skin incision, the straps muscles are retracted. Blood vessels are ligated close to the gland after visualization of the laryngeal nerves.

	Types of thyroidectomy	
1	Total thyroidectomy	Removal of the entire thyroid gland

2	Partial thyroid lobectomy	Removal of a part of a lobe
3	Thyroid lobectomy with isthmusectomy	Removal of the isthmus in addition to a lobe
4	Subtotal thyroidectomy	Removal of a lobe, the isthmus, and part of the other lobe

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