Describe the development of the thyroid gland. What are the anatomical relations of the thyroid. Relate these to the complications of thyroidectomy

Introduction

The thyroid gland is the largest endocrine gland of the body. It produces thyroid hormone, which controls the rate of metabolism in the body, and calcitonin, a hormone controlling calcium metabolism (reducing the serum concentration of calcium). The hormones have affects throughout the body except adult brain, spleen, testes and uterus – as well as itself.

Development of the thyroid gland

The thyroid gland develops from an endodermal thickening of cells that originate from the 3rd branchial pouch. Some cells originate from the 4th branchial pouch. In craniofacial development, the cells move to the base of the tongue to a point known as the foramen caecum. This is where the main anlage of the thyroid develops. (an aggregation of cells in the embryo indicating the first trace of an organ). From the base of the tongue, the anlage descends as the thyroid diverticulum, leaving the thyroglossal duct, which is connected to the foramen caecum – passing anteriorly to the hyoid bone and thyroid cartilage. It settles as a bilobed organ just inferior to the thyroid cartilage, one lobe on each side of the trachea – anterolaterally. The gland lies partly on the cricoid cartilage. The two lobes are joined by an isthmus which unites the lobes over the trachea, anterior to the second and third tracheal rings.

The next stage in the development of the thyroid gland is the appearance of thyroid follicles which occurs between nine and ten weeks in the development of the embryo. The follicle consists of a layer of cells arranged around a big central cavity. The cavity is filled with a colloid like material, consisting largely of the protein thyroglobulin. Three types of cells become apparent. A cells, or perifollicular endothelial cells, are responsible for the blood supply to the follicles. B cells, or follicular cells – the predominant cells having an affinity for iodine and synthesise iodothyronine hormones T_3 and T_4. A and B cells develop from the endoderm. C cells or parafollicular cells produce calcitonin and develop from the ectoderm.

The development of the thyroid gland is controlled by the thyroid stimulating hormone (which is also known as thyrotropin). TSH or thyrotropin is a glycoprotein hormone. The hypothalamus produces and stores thyrotropin-releasing hormone. It is released into the hypothalamic-pituitary portal system and circulates to the anterior pituitary. Here TSH is stored which is consequently stimulated to be released. TSH has a trophic affect on the gland stimulating its growth. The other affects of TSH on the thyroid gland include: increase in release of stored thyroid hormones, increase in thyroid hormone synthesis. As mentioned, these hormones are responsible for regulating the rates of metabolic processes throughout the body.

Upon completion of development of the thyroid, the gland is surrounded by a thin fibrous capsule, which sends septa deeply into the gland. External to the capsule is a loose sheath formed by the visceral layer of the prevertebral deep cervical fascia. Dense connective tissue connects the capsule of the thyroid gland to the cricoid cartilage and the superior tracheal rings.

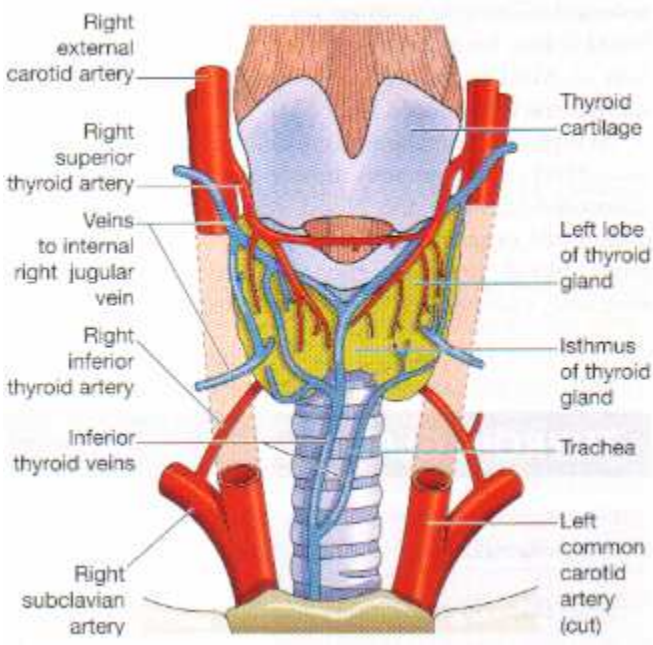
Two pairs of parathyroid glands are normally present. These small glands usually lie external to the fibrous thyroid capsule on the medial half of the posterior surface of each lobe of the thyroid, but within its sheath. The number of glands can vary from two to six. These glands produce parathormone also a regulator of serum calcium increasing levels by resorption of bone.

There are a few embryonic derangements that may occur during development. The gland may retain its position at the base of the tongue, failing to descend from its embryonic origin – resulting in lingual thyroid gland. Alternatively there may be incomplete descent down the thyroglossal duct resulting in the thyroid gland being located high in the neck or just inferior to the hyoid bone. Accessory thyroid tissue may result in a pyramidal lobe, extending superiorly from the isthmus which develops from the remnants of the thyroglossal duct as do thyroglossal duct cysts.

What are the anatomical relations of the thyroid gland?

In order to describe the relations it is first necessary to consider the blood and nerve supply to the thyroid gland – a highly vascular gland.

Arterial supply and venous drainage:



The thyroid gland is a highly vascular gland and has two blood supplies. It is supplied by the superior and inferior thyroid arteries. These vessels lie between the fibrous capsule and the pretracheal deep cervical fascia. The superior thyroid artery is usually the first branch of the external carotid artery. It descends to the superior pole of each lobe of the gland, piercing the pretracheal layer of deep cervical fascia and divides

into anterior and posterior branches. The inferior thyroid artery is the largest branch of the thyrocervical trunk of the subclavian artery. It runs superomedially, posterior to the carotid sheath, to reach the posterior aspect of the thyroid gland. It divides into several branches that pierce the pretracheal fascia to supply the inferior pole of the gland. There are anastomoses across the midline between the left and right arteries and also between the superior and inferior thyroid arteries, explaining the vast supply to the gland.

The thyroid gland has three pairs of veins draining the venous plexus on the anterior surface of the gland. The superior thyroid veins drain the superior poles of the thyroid gland; the middle thyroid veins drain the middle of the lobes; the inferior thyroid veins drain the inferior poles. The superior and middle thyroid veins drain into the internal jugular veins whilst the inferior thyroid veins drain into the brachiocephalic veins, posterior to the manubrium of the sternum.

The thyroid gland does not have a duct. This is because the gland is an endocrine gland, the hormones secreted are directly introduced into the blood, that is, there is no need for a duct.

The lymphatic vessels of the thyroid gland run in the interlobular connective tissue, often associated with the arteries, communicating with a capsular network of lymphatic vessels. The lymphatic drainage can occur via many nodes, including superior deep cervical, inferior deep cervical, pretracheal, prelaryngeal and paratracheal.

The nerve supply of the thyroid gland derives from the superior, middle and inferior cervical sympathetic ganglia. They reach the gland through plexuses that accompany the thyroid arteries. The fibres are vasomotor causing the constriction of the blood vessels. There is no secretomotor supply, since the gland is hormonally controlled via TSH as previously discussed.

Posterior to the gland is the cricoid cartilage and the superior trachea as well as the parathyroid glands. Also medially to gland lie the trachea, recurrent laryngeal nerve larynx and oesophagus. The gland lies between the levels C5 and T1. The gland lies deep to the strap muscles (ansa cervicalis). The two main muscles are sternothyroid and sternohyoid. (The attachment of sternothyroid muscle to the oblique line on the thyroid cartilage has consequences, since it limits the movement of the gland upwards. So growth of the organ, e.g. tumour or goitre, must occur laterally or inferiorly). Lying relatively closely laterally to the gland are the internal jugular vein, common carotid artery and vagus nerve, enclosed within a deep cervical fascial layer known as the carotid sheath.

The two most important relations to the thyroid gland clinically are the recurrent laryngeal nerve and the external laryngeal nerve – both branches of the vagus nerve which run behind the gland in the groove between the oesophagus and trachea. The recurrent laryngeal nerve is intimately related to the inferior thyroid artery and its branches near the inferior pole. The external laryngeal nerve is related to the superior thyroid artery.

Complications of thyroidectomy

Thyroid cancer is a disease where the thyroid cells become abnormal and grow in an unregulated manner forming a cancerous tumour, which has the potential to spread elsewhere – considering its vast lymphatic drainage. Thyroid cancer is the most common endocrine cancer, accounting for ~1% of all cancers. Thyroidectomy is an operation performed to remove some, or all, of the thyroid tissue depending on the severity of the cancer. There are several types the main two being:

a) Bilateral subtotal thyroidectomy - a small remnant of thyroid tissue is left in place on the backside of the thyroid to provide protection for the parathyroid glands and recurrent laryngeal nerves. The isthmus is also removed.
b) Total thyroidectomy - the entire thyroid gland is removed leaving the parathyroid glands.

One possible complication of such surgery is hypoparathyroidism which results in low serum calcium. This can arise due to the blood supply to the parathyroid glands being compromised, or by the removal of the glands with the surgical specimen.

The main complication involves damage to the laryngeal nerves. Due to the extensive blood supply to the highly vascular thyroid gland, the superior and inferior thyroid arteries must be clamped or ligated. However, it was mentioned previously of the intimate relationship of the laryngeal nerves to such arteries, so are at risk.

(One related issue with respect to ligation is the fact that in around 10% of the population there is a third, unpaired, arterial supply. A branch known as thyroidea ima may be present, originating from many alternative arteries. It ascends on the anterior surface of the trachea, which it supplies, and continues to the isthmus of the thyroid where it divides into branches that supply it. As a result, care must be taken to ensure that such a branch is not present, and if it is must be ligated also to prevent bleeding upon removal of the thyroid.)

Near the inferior pole of the thyroid gland, the recurrent laryngeal nerve is intimately related to the inferior thyroid artery and its branches. The nerve may cross anteriorly, posteriorly or between the branches. Because of this relationship, the inferior thyroid arteries must be ligated some distance lateral and inferior to the thyroid gland where it is not close to the nerve. This nerve is responsible for supplying most of the muscles controlling the position of the vocal cords. If it is cut on one side the affected cord will lie in a semi-abducted position, however the other cord will cross the midline to compensate. If both are cut, the cords will both lie in a semi abducted position and speech and coughing becomes impossible. Partial damage of the nerve results in the posterior cricoarytenoids being overpowered by the larger number of muscles closing the cords, so the affected cord is adducted to the midline. If both are damages, both cords will be adducted and rima glottides will close leaving the larynx completely obstructed – resulting in the possible need for a cricothyroidotomy or tracheotomy.

The position of the external laryngeal nerve results in the need for the superior artery having to be ligated as close to the thyroid gland as possible. This nerve supplies motor to the muscle cricothyroid. Lesion results in the inability to vary the length and tension of the cords, resulting in a voice that is monotonous in character.