Part Ten: Thyroid / Parathyroid

Chapter 133: Anatomy

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Development of the Thyroid Gland

The thyroid gland begins as an endodermal bud from the floor of the pharynx between the first and second branchial pouches. Elongation of this bud forms a tubular outgrowth, the thyroglossal duct. Further growth and migration of the thyroglossal duct continue inferiorly or caudally into the neck until the duct lies in a plane anterior to the developing tracheobronchial bud. As development progresses a bilobed organ connected by a midline isthmus is eventually formed. Ultimately the original connection with the floor of the mouth is lost except for a small pit, the foramen caecum, which can usually be seen on the adult tongue lying between the anterior two thirds and posterior one third of the tongue.

Abnormalities in the pattern of thyroid development include arrested growth, accessory tissues, and cystic development of the thyroglossal duct. In the case of arrested development the thyroid gland may not migrate beyond its point of origin in the floor of the pharynx. In later life this may present as a lingual tumor but is, in fact, a lingual thyroid. Lingual thyroid may coexist with other thyroid tissue in the neck, varying from minimal tissue nodules to a hemithyroid or normal thyroid development (Bailey, 1925; Marshall and Becker, 1949). Even when there is normal development of the thyroid gland, there may be accessory thyroid tissue in the region of the neck at any point along the original track of the thyroid gland (Fig. 133-1) or beyond it in the mediastinal space and on rare occasions in the tracheal wall (Fish and Moore, 1963; Myers and Pantangco, 1974).

Thyroglossal cysts are almost always midline masses of the neck and may lie anywhere along the migratory track of the gland from the foramen caecum to the suprasternal space. Thus they may present clinically as a lingual, sublingual, suprahyoid, infrahyoid, or suprasternal mass. The course of the thyroglossal duct during development is in close relationship to the mesenchymal masses of the second and third branchial arches, which eventually aggregate into the cartilaginous precursors of the hyoid bone. Keith (1933) described the course of the duct as traversing the hyoid precursor, whereas Frazer (1926) and Davies (1963) state that it courses anterior to the developing hyoid bone. The latter authors also describe it as having a recurrent course under the inferior surface of the body of the hyoid and passing inferiorly in contact with the thyrohyoid membrane. Because of the close association of the thyroglossal duct to the hyoid. Sistrunk (1920) recommended removal of the midportion or body of the hyoid bone at the time of surgical excision of a thyroglossal duct cyst to prevent recurrence of the cyst. In a histologic study of 200 laryngeal tissue blocks that included the tongue, Ellis and Van Nostrand (1977) found remnants of the thyroglossal duct in 7% of the specimens. Although the remnants were in some cases adherent to the hyoid bone, none were trapped within it, corroborating the descriptions of Frazer (1926) and Davies (1963). The "Sistrunk" operation is still current in its original intent and the most effective technique of preventing recurrence of thyroglossal duct cysts (Deane and Telander, 1978).

Development of the Parafollicular Cells

In addition to the principal cells of the thyroid gland, which form the thyroid follicles and produce thyroglobulin, there is a second type of cell, which lies in the parafollicular space and is responsible for the secretion of thyrocalcitonin. These cells have had varied names such as parafollicular, clear, or "C" cells of the thyroid gland. Although in past years there were several hypotheses regarding both the embryologic origin and the function of these cells, it was not until the late 1960s that these were clarified (Pearse and Polak, 1971). Initially it was believed that the "C" cells were derived embryologically from the endoderm of the ultimobranchial body. The ultimobranchial body is variably described as being part of the fourth, fifth, or sixth pharyngeal pouch. This area of the pharynx has also been named the "caudal pharyngeal complex" by Grosser (1912), a term that is still used by some authors in current descriptions of this area (Davies, 1963; Warwick and Williams, 1980). More recently, it has been demonstrated that "C" cells are derived from neural crest cells that migrate ventrally, seeding the ultimobranchial body. Subsequently, they migrate into the ventral part of the neck and are incorporated into the thyroid gland (Pearse and Polak, 1971).

Development of the Parathyroid Glands

The parathyroid glands are also endodermal derivatives of the pharyngeal wall, but whereas the thyroid gland arises in the midline, the parathyroid glands are derived from the third and fourth pharyngeal pouches. The superior parathyroid gland (parathyroid IV) is derived from the fourth pouch, and the inferior parathyroid gland (parathyroid III) is derived from the epithelium of the superior portion of the third pouch. This seems paradoxical, but is explained on the basis of the additional migration by the cells in the third branchial pouch. As in the case of thyroid development, these cells may also be arrested in their migration or migrate beyond the thyroid gland into the mediastinum.

Anatomy of the Thyroid Gland

The thyroid gland, as its Greek root implies, is shield shaped, although its form varies considerably, sometimes more H or U shaped (Fig. 133-2). Each of the elongated, lateral lobes of the thyroid gland consists of a superior and an inferior pole. In the average subject, the thyroid isthmus overlies the third tracheal ring, although in others it may be absent, so that the gland exists as two distinct lobes. It is usually firmly attached to the trachea by the visceral or pretracheal fascia, a division of the middle layer of deep cervical fascia. The firm attachment of the gland to the laryngotracheal skeleton is of assistance in differential diagnosis of neck masses, since thyroid masses will move with swallowing whereas branchial cysts and dermoid cysts will not. In addition to fascial coverings, there is a true capsule of fibrous tissue that sends interlacing septal fibers into the stroma of the gland. The superior pole of the thyroid gland may extend superiorly as far as the oblique line of the thyroid cartilage, where it lies under cover of the sternothyroid and sternohyoid muscles. The inferior pole may extend inferiorly as far as the fifth or sixth tracheal ring.

In some cases the distal part of the thyroglossal duct appears to serve as a guide for glandular development to proceed superiorly in the neck. This forms a pyramid-shaped lobe, extending from the isthmus or midportion of one of the lateral lobes, as far superiorly as the hyoid bone, to which it may be attached. On rare occasions there is a slip of muscle, the levator of the thyroid gland, which attackes the thyroid gland to the hyoid bone (Hollinshead, 1968).

Anatomy of the Parathyroid Glands

The parathyroid glands usually consist of four, flattened ovoid structures, measuring approximately 6 mm in height, 2 mm in width, and 1 to 2 mm in thickness. Size and number, however, are quite variable. The superior pair of glands are more constant in position, being located on the posterior aspect of the superior pole of the lateral lobes of the thyroid gland and close to the recurrent laryngeal nerve (Fig. 133-3). The inferior parathyroid glands are substantially more varied in their position on the posterior aspect of the inferior pole of the thyroid gland. For this reason, pathologic enlargements of the inferior parathyroid glands may extend inferiorly either anterior to the trachea or posterior to the esophagus (see the reviews by Warwick and Williams, 1980).

The primary role of the parathyroid hormone (PTH) is to maintain serum calcium and phosphorus levels and maintain a homeostatic concentration of extracellular calcium (Potts, 1977). This is accomplished by stimulating osteoclastic activity, mobilizing calcium from bone, and inhibiting renal tubular excretion of calcium ion. An equilibrium of serum calcium is maintained by the reciprocal action of thyrocalcitonin from thyroid parafollicular cells ("C" cells), which inhibits osteoclastic activity and stimulates calcium excretion in the kidney.

Blood Supply of the Thyroid Gland

The thyroid gland receives a dual blood supply, from the superior and inferior thyroid arteries, which have abundant collateral anastomoses with each other, both ipsilaterally and contralaterally (Fig. 133-2). Because of the common frequency of thyroidectomy and ligation of the thyroid blood supply, the pattern of its vascular pedicles is important to the surgeon. In addition, all arteries supplying the thyroid gland are accompanied by motor nerves to the larynx and thus are in jeopardy during ligation of the thyroid blood supply (Nordland, 1930).

Superior thyroid artery

The superior thyroid artery is the first anterior branch of the external carotid artery. In a small percentage of cases it may arise from the common carotid artery just before its bifurcation in the internal and external branches (see Fig. 133-2). Although this is of no consequence itself, it may confuse the surgeon, resulting in inadvertent ligation of the common carotid artery instead of the external carotid artery in certain operations. The superior thyroid artery descends the lateral aspect of the neck under the cover of the superior belly of omohyoid and sternothyroid muscles. It is prominent on the anterior border of the lateral lobe as it runs superficially toward the isthmus to anastomose with the artery of the opposite side. Above the level of the superior pole of the thyroid gland, the artery is accompanied by the external laryngeal branch of the superior laryngeal nerve. This nerve parallels the artery until it reaches the superior lobe of the thyroid gland, where it courses medially under the sternothyroid muscle to supply the cricothyroid muscle. High ligation of the superior thyroid artery places this nerve in jeopardy and in some cases the superior laryngeal nerve as well. Division of the external laryngeal nerve may produce dysphonia because it denervates the cricothyroid muscle, which assists in the regulation of pitch. In addition, it introduces an asymmetric rotatory force on the cricoid cartilage, which, in turn, causes an asymmetric tension in the vocal cords. If the superior laryngeal nerve is divided, there is, in addition to the motor deficit of external laryngeal nerve palsy, a sensory deficit affecting the distribution of the superior laryngeal nerve. This is also clinically important because the internal laryngeal nerve provides sensation to the mucosa of the piriform sinus and false vocal folds, which is the afferent portion of the protective reflex of the laryngeal inlet. Near the upper pole of the lateral lobe, the superior thyroid artery sends a small branch, the cricothyroid artery, across the cricothyroid muscle toward the midline (see Fig. 133-2). The vessel anastomoses with its opposite member in the midline on the surface of the median cricothyroid ligament. The vessel is important clinically because it may be lacerated during cricothyroidotomy or coniotomy either by the incision or the cannula as it is placed in the median cricothyroid ligament to provide an emergency airway.

Inferior thyroid artery

The inferior thyroid artery arises from the thyrocervical trunk, a branch of the first part of the subclavian artery at the level of the first rib (see Fig. 133-2). It ascends vertically for a short distance before turning medially, forming an arching loop and entering the tracheoesophageal groove (see Figs. 133-2 and 133-3). Most of its small branches penetrate the posterior aspect of the lateral lobe, but there is a longitudinal branch that anastomoses with the superior thyroid artery near the superior pole. In contrast, the superior thyroid artery lies on the anterior aspect of the lateral lobe, sending its branches deep into the substance of the gland. Because of the branching pattern of the inferior thyroid arteries, small vessels frequently intermingle with the recurrent laryngeal nerve as it occupies the tracheoesophageal groove before entering the larynx at the level of the cricoid cartilage. Small branches from the recurrent laryngeal nerve to the esophagus at this point also provide an intermingling of nerve and vascular branches. Nordland (1930) has described several variations in the relationship of the recurrent laryngeal nerve and inferior thyroid artery. Surgery in this region is complicated by the tethering of the inferior pole of the lateral lobe to the trachea by the visceral fascia. Attempts to mobilize the lobe to either identify the recurrent laryngeal nerve or ligate the inferior thyroid artery are difficult.

Venous drainage of the thyroid gland

Although the thyroid gland is supplied by two pairs of arteries, three pairs of veins provide venous drainage (Fig. 133-4). The superior thyroid vein parallels the course of the superior thyroid artery on the anterior surface of the thyroid as it ascends to become a tributary of the internal jugular vein. A middle thyroid vein, usually the shortest of the three pairs of veins, has a direct lateral course from the surface of the thyroid to the internal jugular vein. The inferior thyroid vein lies on the anterior surface of the thyroid gland compared with the posterior position of the inferior thyroid artery. It has an almost vertical course downward before entering the brachiocephalic vein.

Innervation of the Thyroid and Parathyroid Glands

The principal innervation of the thyroid and parathyroid glands is derived from the autonomic nervous system. Parasympathetic fibers are distributed from the vagus nerves, and sympathetic fibers descend from the superior, middle, and inferior sympathetic ganglia of the sympathetic trunk. The specific role of the autonomic nervous system in relation to glandular secretion is not clearly understood, but it is postulated that most of the effect is on blood vessels and the perfusion rates of the glands.

Surgeon's Viewpoint

Recognition of the important aspects of the anatomy encountered in thyroidectomy help protect the superior laryngeal nerve, recurrent laryngeal nerve, and parathyroid glands. If the disease permits, the thyroid isthmus is divided to expose the trachea and cricothyroid muscle at its anterior end. The trachea is always the reference point during surgery. The thyroid is then separated from the carotid sheath with division of the middle thyroid vein when present. The dissection is carried superiorly along the thyroid toward the superior pole. On the right side, a non-recurrent nerve (1% of population) can be identified crossing from the carotid sheath toward the thyroid and ultimately to the cricothyroid joint area.

With this anatomy exposed, the superior pole of the thyroid is approached with care to protect the external branch of the superior laryngeal nerve. The superior pole is separated from the cricothyroid muscle fascia gently as the external branch of the nerve crosses this space to innervate the muscle. If the nerve is identified, then it must be cleared of the superior pole and the superior thyroid artery and vein. If the nerve is not seen crossing this space, then the superior vessels may be ligated at the superior aspect of the thyroid gland.

The recurrent laryngeal nerve is identified by placing traction on the superior thyroid pole anteromedially. The left recurrent nerve lies in the tracheoesophageal groove, whereas the right approaches the gland from a more lateral approach. The nerve on either side can frequently be palpated. The nerve crosses over, under, or between branches of the inferior thyroid artery. The recurrent nerve can divide into two or more branches at or just inferior to the artery. This division increases the potential risk of injury and requires patience and precision. Isolation of the artery and knowledge of the trachea and esophagus allow dissection of the nerve inferior to the artery. This is the common location for identification of the nerve; the dissection is then carried superiorly.

After identification of the inferior thyroid artery and recurrent nerve, traction is placed on the inferior pole in an anteromedial direction. This allows inspection of the thyroid capsule for parathyroid tissue. Observation of the inferior thyroid artery branches can lead to the parathyroid glands. The lobe is dissected away from the nerve by separating the arterial branches to the thyroid gland. This protects the recurrent nerve and the parathyroid blood supply. At Berry's ligament, care must be taken because the nerve is held tightly to this area and because a branch of the artery is located adjacent to the ligament. Transection of this ligament frees the nerve and allows the thyroid gland to be removed from its bed. Thus for surgery of the thyroid compartment, the cricothyroid muscle, trachea, esophagus and inferior thyroid artery are essential landmarks in the preservation of the superior laryngeal nerve, recurrent laryngeal nerve, and parathyroid glands.