



A cadaveric study of anomalous development of thyroid gland in population from Bihar

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Abstract

Embryological the PL of the thyroid gland is derived from remnant of the thyroglossal duct situated in the pre-tracheal region between the isthmus and the hyoid bone during the descent of the foetal lingual thyroid to its normal anatomical position in intrauterine life. The PL may originate from the isthmus or on either lobe of thyroid gland, with a slight predilection for the left lobe. There are instances where non-removal of pyramidal lobe during a total thyroidectomy for a thyroid carcinoma can lead to recurrence of the disease. Developmental anomalies cause various morphological abnormalities in thyroid gland. Thyroid diseases are well documented and require medical and surgical interventions. Hence the present study was planned to study the anomalous development of thyroid gland in cadavers from Bihar region.

The present study was planned in the Department of Anatomy, Anugrah Narayan Magadh Medical College, Gaya, Bihar from July 2016 Dec 2016. Total 25 cadavers were selected in the present study. The present study was planned to study the anomalous development of thyroid gland in cadavers from Bihar region.

The data generated from the present study concludes that Morphology of the thyroid gland was studied in detail to find any anatomical variations and developmental anomalies. Recognition of anomaly is important to avoid unnecessary contralateral neck exploration with its potential morbidity and to ensure that all patients receive careful follow-up and appropriate thyroid hormone therapy when necessary. The knowledge of the various developmental anomalies of the thyroid gland and the variations in the neurovascular relations will help the surgeons in the better planning of a safe and effective surgery. Imaging of pyramidal lobe preoperatively especially in patients requiring total thyroidectomy would facilitate the treatment and monitoring of patient by decreasing relapses that may occur at a later time.

Keywords: thyroid gland, pyramidal lobe, Isthmus, etc

Introduction

The thyroid gland, or simply the thyroid, is an endocrine gland in the neck, consisting of two lobes connected by an isthmus. It is found at the front of the neck, below the Adam's apple. The thyroid gland secretes three hormones, namely the two thyroid hormones (thyroxine/T4 and triiodothyronine/T3), and calcitonin. The thyroid hormones primarily influence the metabolic rate and protein synthesis, but they also have many other effects, including effects on development. Calcitonin plays a role in calcium homeostasis [1].

Hormonal output from the thyroid is regulated by thyroid-stimulating hormone (TSH) secreted from the anterior pituitary gland, which itself is regulated by thyrotropin-releasing hormone (TRH) produced by the hypothalamus [2]. The thyroid may be affected by several diseases. Hyperthyroidism occurs when the gland produces excessive amounts of thyroid hormones, the most common cause being Graves' disease, an autoimmune disorder. In contrast, hypothyroidism is a state of insufficient thyroid hormone production. Worldwide, the most common cause is iodine deficiency. Thyroid hormones are important for development, and hypothyroidism secondary to iodine deficiency remains the leading cause of preventable intellectual disability [3]. In iodine-sufficient regions, the most common cause of hypothyroidism is Hashimoto's thyroiditis, also an autoimmune disorder. In addition, the thyroid gland may also develop several types of nodules and

thyroid cancer.

The thyroid gland is a butterfly-shaped organ that sits at the front of the neck. It is composed of two lobes, left and right, connected by a narrow isthmus. The thyroid weighs 25 grams in adults, with each lobe being about 5 cm long, 3 cm wide and 2 cm thick, and the isthmus about 1.25 cm in height and width. The gland is usually larger in women, and increases in size in pregnancy [4,5].

The thyroid sits near the front of the neck, lying against and around the front of the larynx and trachea [4]. The thyroid cartilage and cricoid cartilage lie just above the gland, below the Adam's apple. The isthmus extends from the second to third rings of the trachea, with the uppermost part of the lobes extending to the thyroid cartilage, and the lowermost around the fourth to sixth tracheal rings [6]. The thyroid gland is covered by a thin fibrous capsule, which has an inner and an outer layer. The outer layer is continuous with the pretracheal fascia, attaching the gland to the cricoid and thyroid cartilages, via a thickening of the fascia to form the posterior suspensory ligament of thyroid gland also known as Berry's ligament. This causes the thyroid to move up and down with swallowing [5]. The inner layer extrudes into the gland and forms the septae that divides the thyroid tissue into microscopic lobules. Typically four parathyroid glands, two on each side, lie on each side between the two layers of the capsule, at the back of the thyroid lobes.

The infrahyoid muscles lie in front of the gland and the sternocleidomastoid muscle to the side. Behind the outer

wings of the thyroid lie the two carotid arteries. The trachea, larynx, lower pharynx and esophagus all lie behind the thyroid. In this region, the recurrent laryngeal nerve [8] and the inferior thyroid artery pass next to or in the ligament [7]. The thyroid is supplied with arterial blood from the superior thyroid artery, a branch of the external carotid artery, and the inferior thyroid artery, a branch of the thyrocervical trunk, and sometimes by an anatomical variant the thyroid ima artery, which has a variable origin. The superior thyroid artery splits into anterior and posterior branches supplying the thyroid, and the inferior thyroid artery splits into superior and inferior branches. The superior and inferior thyroid arteries join together behind the outer part of the thyroid lobes. The venous blood is drained via superior and middle thyroid veins, which drain to the internal jugular vein, and via the inferior thyroid veins. The inferior thyroid veins originate in a network of veins and drain into the left and right brachiocephalic veins [4]. Both arteries and veins form a plexus between the two layers of the capsule of the thyroid gland.

Lymphatic drainage frequently passes the prelaryngeal lymph nodes (located just above the isthmus), and the pretracheal and paratracheal lymph nodes. The gland receives sympathetic nerve supply from the superior, middle and inferior cervical ganglion of the sympathetic trunk. The gland receives parasympathetic nerve supply from the superior laryngeal nerve and the recurrent laryngeal nerve. There are many variants in the size and shape of the thyroid gland, and in the position of the embedded parathyroid glands [5].

Sometimes there is a third lobe present called the pyramidal lobe [5]. When present, this lobe often stretches up the hyoid bone from the thyroid isthmus and may be one to several divided lobes [4]. The presence of this lobe ranges in reported studies from 18.3% to 44.6%. It was shown to more often arise from the left side and occasionally separated. The pyramidal lobe is also known as Lalouette's pyramid [8]. The pyramidal lobe is a remnant of the thyroglossal duct which usually wastes away during the thyroid gland's descent [5]. Small accessory thyroid glands may in fact occur anywhere along the thyroglossal duct, from the foramen cecum of the tongue to the position of the thyroid in the adult [4]. A small horn at the back of the thyroid lobes, usually close to the recurrent laryngeal nerve and the inferior thyroid artery, is called Zuckerkandl's tubercle [7].

Other variants include a levator muscle of thyroid gland, connecting the isthmus to the body of the hyoid bone [5], and the presence of the small thyroid in artery. The primary function of the thyroid is the production of the iodine-containing thyroid hormones, triiodothyronine (T3) and thyroxine (T4) and the peptide hormone calcitonin. The thyroid hormones are created from iodine and tyrosine. T3 is so named because it contains three atoms of iodine per molecule and T4 contains four atoms of iodine per molecule. [9] The thyroid hormones have a wide range of effects on the human body. The thyroid hormones increase the basal metabolic rate and have effects on almost all body tissues. Appetite, the absorption of substances, and gut motility are all influenced by thyroid hormones. They increase the absorption in the gut, generation, uptake by cells, and breakdown of glucose. They stimulate the breakdown of fats, and increase the number of free fatty acids. Despite increasing free fatty acids, thyroid hormones

decrease cholesterol levels, perhaps by increasing the rate of secretion of cholesterol in bile [10].

The hormones increase the rate and strength of the heartbeat. They increase the rate of breathing, intake and consumption of oxygen, and increase the activity of mitochondria. Combined, these factors increase blood flow and the body's temperature. Thyroid hormones are important for normal development. They increase the growth rate of young people, and cells of the developing brain are a major target for the thyroid hormones T3 and T4. Thyroid hormones play a particularly crucial role in brain maturation during fetal development and first few years of postnatal life [10].

The thyroid hormones also play a role in maintaining normal sexual function, sleep, and thought patterns. Increased levels are associated with increased speed of thought generation but decreased focus. Sexual function, including libido and the maintenance of a normal menstrual cycle, are influenced by thyroid hormones [10].

Embryological the PL of the thyroid gland is derived from remnant of the thyroglossal duct situated in the pre-tracheal region between the isthmus and the hyoid bone during the descent of the foetal lingual thyroid to its normal anatomical position in intrauterine life. The PL may originate from the isthmus or on either lobe of thyroid gland, with a slight predilection for the left lobe. There are instances where non-removal of pyramidal lobe during a total thyroidectomy for a thyroid carcinoma can lead to recurrence of the disease. Developmental anomalies cause various morphological abnormalities in thyroid gland. Thyroid diseases are well documented and require medical and surgical interventions. Hence the present study was planned to study the anomalous development of thyroid gland in cadavers from Bihar region.

Methodology

The present study was planned in the Department of Anatomy, Anugrah Narayan Magadh Medical College, Gaya, Bihar July 2016 to Dec 2016. Total 25 cadavers were selected in the present study. The present study was planned to study the anomalous development of thyroid gland in cadavers from Bihar region.

Cadavers with no scars in the cervical region, suggesting that the patient have not undergone any surgery were included in the study. The midline of the neck was dissected to expose the thyroid gland. A skin incision was made from chin to sternum in midline. The flap of skin was reflected inferolaterally and platysma was reflected upwards. Deep fascia was incised immediately above the sternum and extended along anterior border of sternocleidomastoid. The fat and fascia was removed from the margins of the sternocleidomastoid. The sternocleidomastoid was retracted and the deep fascia removed from the anterior belly of digastric to expose the infrahyoid muscles. The muscles were separated in the midline to expose the pretracheal fascia and the isthmus of TG. The infrahyoid muscles were reflected upwards to expose the lobes of the thyroid gland. Various parameters like length of the lateral lobes, height of isthmus, presence of pyramidal lobe and levator thyroidae glandulae, arteries supplying, and termination of the veins draining the thyroid gland were recorded. Approval of the institutional ethical committee was taken prior to conduct of this study.

Results & Discussion

Many morphological variations and developmental anomalies of the thyroid gland have been reported in the literature. The common anomalies are persistence of pyramidal lobe and thyroglossal duct cyst. Some rare anomalies are agenesis of thyroid gland, aberrant thyroid gland and agenesis of isthmus. Pyramidal lobe forms a long pyramid which is attached by its base to the superior border of the isthmus, usually at its junction with the left lobe. Its apex is attached to the body of the hyoid bone by a fibrous band, which sometimes contains muscular fibres, known as the Levator Glandulae Thyroideae (LGT). It is seldom midline in position [11]. Disturbed organogenesis of thyroid gland in humans leads to a variety of morphological variations of gland. The developmental anomalies of the gland may cause clinical, functional disorders and various thyroid illnesses [12].

A view given by various authors regarding the morphology of Thyroid gland and its anomalies with Levator Glandulae Thyroideae in particular, provokes much interest. By fourth week of development [On Day 24] during embryonic period the thyroid gland appears first as a median thickening, which is soon converted into a solid cellular cord-like structure between the 1st and 2nd Pharyngeal pouches and is named the so called ‘Thyroglossal duct’. The lower end of the duct bifurcates and forms Right and Left lobes which is later united by a bridge crossing the midline called as ‘Isthmus’, and simultaneously the upper end degenerates [13].

The data from the 25 samples were collected and presented as below. Agenesis of the thyroid isthmus is the complete and congenital absence of the thyroid isthmus as is defined by Pastor *et al.* [14]. In their study, they had reported agenesis of isthmus of thyroid gland with enlarged lobes in a Caucasian cadaver. Marshall documented the variations in the gross structure of the thyroid gland in 60 children, varying in age from a few weeks to 10 years and the absence of the isthmus was reported to be 10% in this group [16]. Ranade *et al* reported absence of isthmus in 35 out of 105 cases (33%), of which 8 were female cadavers [15]. According to Gruber, the incidence of agenesis of isthmus is about 5% [17]. According to the study by Braun *et al*, the isthmus was missing in 4 cases of the 58 cadavers they studied [18].

The pyramidal lobe (PL) should be looked for, while thyroidectomy and removed, as failure of its identification can result in incomplete resection of thyroid gland [19]. Pyramidal lobe course can be from the isthmus, or the left or right lobe of thyroid, upwards in the form of a short stump or a long process that can reach the upper border of the thyroid cartilage or even the hyoid bone. Since Laloutte gave this entity its name in 1789, also called as Laloutte’s lobe [20].

Embryologically the TG develops as a median thickening of the endoderm on the floor of pharynx between the first and second pharyngeal pouches a point later indicated by the foramen caecum. Subsequently, the area invaginates in front of the pharyngeal gut to form a bilobed diverticulum. This thyroid diverticulum grows in allometric proliferation, becoming a solid cellular cord called thyroglossal duct. The duct grows caudally and bifurcates to give rise to the thyroid lobes and the isthmus. As the caudal migration is taking place, the cephalic end of the duct degenerates [21]. Rarely, a high separation of the thyroglossal duct can engender two independent thyroid lobes and pyramidal lobes with the absence of isthmus [22]. Further developments, the TG descends in front of the hyoid bone and the laryngeal cartilages. It reaches its final position in front of the trachea in the 7th week. By then it has acquired a small median isthmus and two lateral lobes. Small detached masses of thyroid tissue may occur above the lobes or isthmus as accessory thyroid glands. Vestiges of thyroglossal duct may persist between the isthmus and the foramen caecum of the tongue, sometimes as accessory nodules or cysts of thyroid tissue.

The agenesis of isthmus is an anomaly of embryological development. The two types of endocrine cells in adult thyroid gland are follicular and parafollicular cells or ‘C’ cells, which are derived from two different embryological cell families. The follicular cells are derived from the endodermic cells of the primitive pharynx and the parafollicular cells from the neural crest. The thyroid gland begins to develop as a median thickening of endoderm on the floor of the pharynx between the first and second pharyngeal pouches. This area later invaginates to form the median diverticulum, which appears in the later half of the fourth week. This thyroid diverticulum grows in allometric proliferation, becoming a solid cellular cord called the thyroglossal duct. The duct grows caudally and bifurcates to give rise to the thyroid lobes and the isthmus. At the same time that its caudal growth is taking place, the cephalic end of the thyroglossal duct degenerates. A high division of the thyroglossal duct can generate two independent thyroid lobes with the absence of isthmus. The absence of the isthmus can be associated with other types of dysorganogenesis, such as the absence of a lobe or the presence of ectopic thyroid tissue [23].

The size and shape of thyroid gland may alter with age, gender, race physiological condition and geographical location. It may be larger and heavier in females than males and hypertrophies during menstruation & pregnancy as reported by Fakhrol AHB *et al.* [24]. Diseases of thyroid like goiter, thyrotoxicosis, adenomas, carcinoma etc. Are usually associated with enlargement of gland and require medical and surgical intervention by Strachan MW J. [25]. The variations of thyroid are due to partial persistence of median or thyro glossal duct by Melnick JC *et al.* [26] and developmental failure results in agenesis or hemiagenesis

Table 1: Posterior relation of isthmus to tracheal rings

Related structure	No. of Cases
1st and 2nd rings	2
1st, 2nd and 3rd rings	6
2nd, 3rd and 4th rings	11
2nd and 3rd rings	3
3rd and 4th rings	3
Present in Total	25

Table 2: The gross anatomical features of the thyroid gland

	Right	Left	Isthmus
Pyramidal lobe	2	5	6
LGT (levator glandulae thyroideae)	2	4	5

Table 3: Height and thickness of the thyroid gland lobes

	Height	Thickness
Right Lobe	3.9 ± 1.1	1.2 ± 0.3
Left Lobe	4.0 ± 0.9	1.1 ± 0.2

that may be unilateral by Kaplaw EL *et al.* [27] Thyroid hemiagenesis and case report incidentally discovered papillary carcinoma of thyroid reported by Pizzini *et al.* [28] Pastor *et al.* [29] defined the agenesis of the thyroid isthmus as the complete and congenital absence of the thyroid isthmus. The isthmus may be missing in the amphibians, birds and among mammals - monotremes, certain marsupials, cetaceans, carnivores and rodents. In rhesus monkey (*Macacus rhesus*) thyroid gland is normal in position but there is no isthmus [30]. A comparative study of anatomy suggests that isthmus connecting the two lobes appeared during the course of evolution. The morphological difference in the evolutionary origin does not result in any changes in the thyroid function [29].

Conclusion

The data generated from the present study concludes that Morphology of the thyroid gland was studied in detail to found any anatomical variations and developmental anomalies. Recognition of anomaly is important to avoid unnecessary contralateral neck exploration with its potential morbidity and to ensure that all patients receive careful follow-up and appropriate thyroid hormone therapy when necessary. The knowledge of the various developmental anomalies of the thyroid gland and the variations in the neurovascular relations will help the surgeons in the better planning of a safe and effective surgery. Imaging of pyramidal lobe preoperatively especially in patients requiring total thyroidectomy would facilitate the treatment and monitoring of patient by decreasing relapses that may occur at a later time.

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