MORPHOMETRIC EVALUATION OF VARIOUS TOPOGRAPHY OF THYROID GLAND FOR SURGICAL CRUCIALITY: AN OBSERVATIONAL CADAVERIC STUDY.

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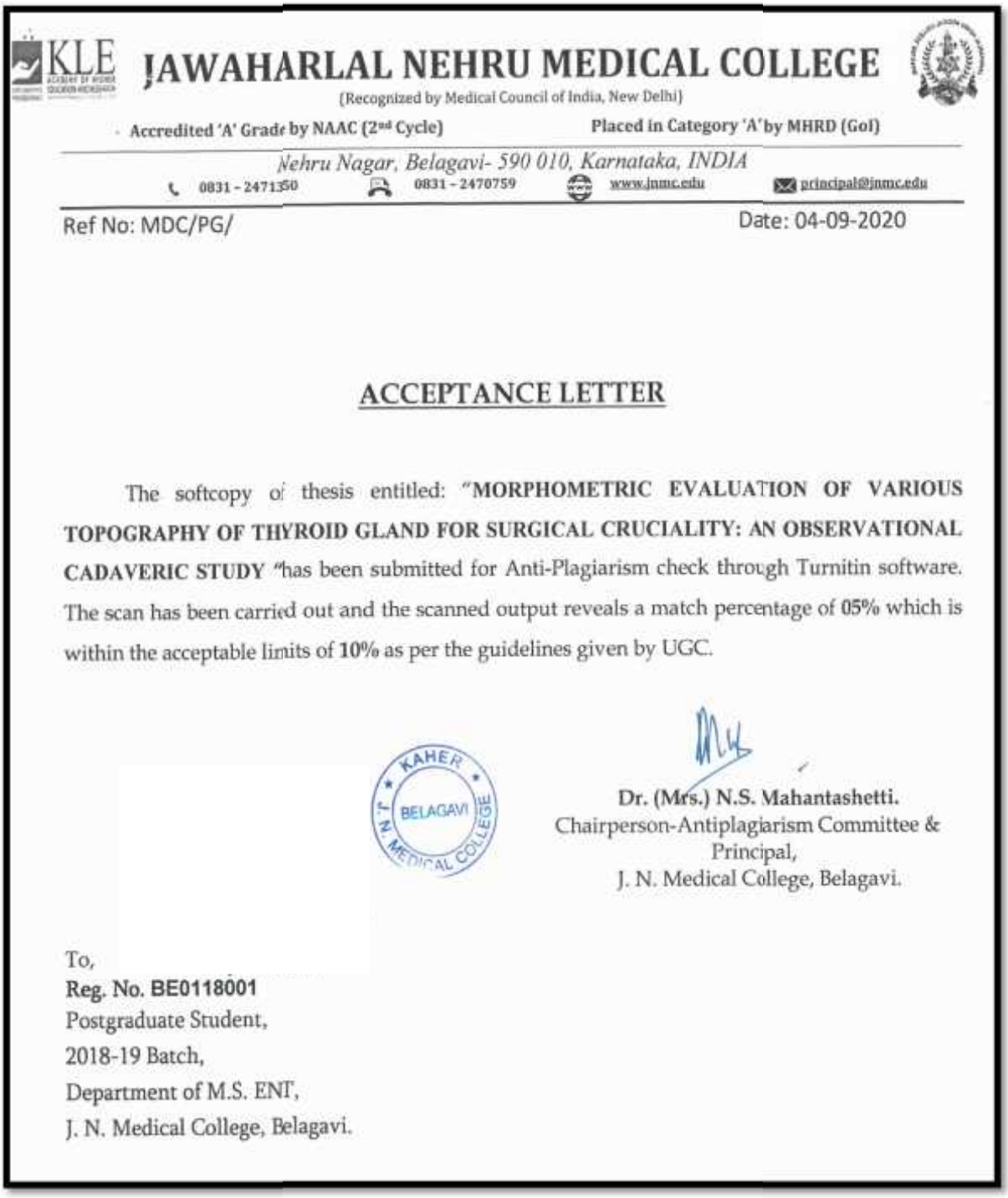

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LIST OF ABBREVIATIONS

THY-GL	Thyroid Gland
PYR-L	Pyramidal Lobe
LGT	LevatorGlandulaeThyroidae
STA	Superior Thyroid Artery
CC	Carotid Bifurcation
LA	Lingual Artery
FA	Facial Artery
HN	Hypoglossal Nerve
ECA	External Carotid Artery
ICA	Internal Carotid Artery
CCA	Common Carotid Artery
SLA	Superior Laryngeal Artery
AGB	Anterior Glandular Branch
PGB	Posterior Glandular Branch
ITA	Inferior Thyroid Artery
IJV	Internal Jugular Vein
RLN	Recurrent Laryngeal Nerve
EBSLN	External Branch of Superior Laryngeal Nerve
LB	Ligament of Berry
ZT	Zuckerkandl’s Tubercle
SP	Superior Parathyroid
TC	Thyroid Cartilage
mm	Millimetres

ABSTRACT

Background- Knowledge about anatomy is extremely necessary for any surgeon, regardless of medical area. Thyroid Gland, due to it's the small size and variations in anatomy and morphology make the intervention or diagnosis challenging, requiring expert professionals to obtain success. A safe thyroid surgery requires a sufficient understanding of normal anatomy and anatomical variations associated with it and its surrounding relations to prevent complications.

Objective- To study morphometric details, anatomical distribution and variations of Thyroid gland and its surrounding relations for surgical implications.

Material and methods: This cadaveric observational study was conducted in the department of Otorhinolaryngology and Head and Neck Surgery and Department of Anatomy of KAHER's Jawaharlal Nehru Medical College and KLES Dr.PrabhakarKore Hospital and Medical Research Center, Belagavi from January 2019 to December 2019. On 40 fresh frozen cadavers neck dissection was performed to study morphometric details, anatomical variations of thyroid gland and its related vessels and nerves. All measurements were recorded using digital calliper sensitive to 0.01 mm and photographs were documented

Result- Forty cadavers of variable age and gender were studied about thyroid gland and its extensions, the pyramidal lobe (PYR-L) and levatorglandulaethyroidae (LGT). The present study showed presence of PYR-L in 52%. The location of the origin of the superior thyroid artery (STA) according to the carotid bifurcation was evaluated as above (25%), below (35%) and at the same level (40%). The distribution patterns of the STA were classified into six types depending on the branching pattern. Typical

and variant glandular branching patterns were observed in 85% and 15% of the specimens, respectively.

Topography of recurrent laryngeal nerve (RLN) was studied in relation to inferior thyroid artery (ITA), ligament of Berry (LB), and Zuckerkandl'stubercle (ZT). The RLN is predominantly a posterior relation of the ITA (86.25%). The tubercle of Zuckerkandl, when present, is a useful landmark for locating the RLN and showed in 46.25% RLN ran deep to it. The LB also make a reliable landmark to the identification of the RLN.

The EBSLN has a variable relation with STA which was observed to lie at a distance of <1cm from STA in 66.25%. In our study ZT formed a useful and constant landmark for superior parathyroid.

Conclusion- Surgeons should be careful in performing routine surgical procedures in the area of the vital structures in neck like thyroid gland, larynx and should be aware of the possible dimensions and variations that can be present in the region to avoid complications.

Keywords:thyroid gland, pyramidal lobe, superior thyroid artery, recurrent laryngeal nerve, inferior thyroid artery, Zuckerkandl's tubercle.

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INTRODUCTION

Comprehensive knowledge about anatomy is of utmost importance to a surgeon. Especially in regards to thyroid gland, its small size and variation in anatomy make it a challenge for diagnosis and intervention.[1]

Thyroid gland is a butterfly shaped organ surrounding the anterolateral aspect of trachea in root of neck, has three parts a right and left lobe joined by isthmus in midline.

Superior and inferior thyroid arteries are the major blood supply to the gland and venous drainage is via thyroid veins (superior, inferior and middle). Lying with in pre tracheal fascia, posterior to strap muscles, it has attachments at facial condensation (Berry's ligament) which fixes it to larynx and trachea just anterior to cricoarytenoid region on each side.

Its surgical important relationships are with left and right recurrent laryngeal nerves and to parathyroid glands.

Major concern during thyroidectomy is to preserve recurrent laryngeal nerve (RLN), external branch of superior laryngeal nerve(EBSLN), parathyroids and vessels supplying thyroid and parathyroid. Injury to these structures result in morbidity which includes bleeding, hoarseness of voice, dysphagia, vocal cord paralysis, hypocalcaemia.[2]

Therefore, a proper understanding of the anatomy and the variations associated with itand its surrounding relations with applied aspect is required for a safe and successful surgery of thyroid.[3]

To know the detailed morphometry on thyroid gland and variations in its surrounding relations during thyroid surgeries is difficult. Hence, studying them in cadavers gives better understanding about surgical anatomy of thyroid gland and its surrounding relations.

OBJECTIVE

To study morphometric details, anatomical distribution and variations of thyroid gland and its surrounding relations for surgical implications.

REVIEW OF LITERATURE

ANATOMY OF THE THYROID AND PARATHYROID GLANDS

EMBRYOLOGY

THYROID GLAND

Thyroid begins to develop from 3rd week to 11th week of gestation. During 3rd week, at the caudal part of tuberculumimpar, an epithelial proliferation appears forming the primordium of medial part of thyroid.[4] The endodermal invagination in floor of pharynx, the foramen cecum Is the point of origin of the thyroid. The thyroid starts descending from pharyngeal floor by end of 7th week of gestation.[5]

Lateral and medial thyroid primordia joins 5th week of gestation providing 30% of the weight of the gland.[6] By the 7th week, there is median isthmus and two lateral lobes.[4-9]

PARA THYROID GLAND

Parathyroid develops from 3rd and 4th pharyngeal pouches and its origin is endodermal.

Superior parathyroid originate from 4th pharyngeal pouch, they attach thyroid at level of upper 1/3rd of posterior surface. Inferior parathyroid originates from the dorsal wing of the 3rd pharyngeal pouch. Thymus originates from ventral wing during the 5th week. Final position in mediastinum is reached after detaching from pharyngeal wall and travelling caudally with the thymus.[10,11]

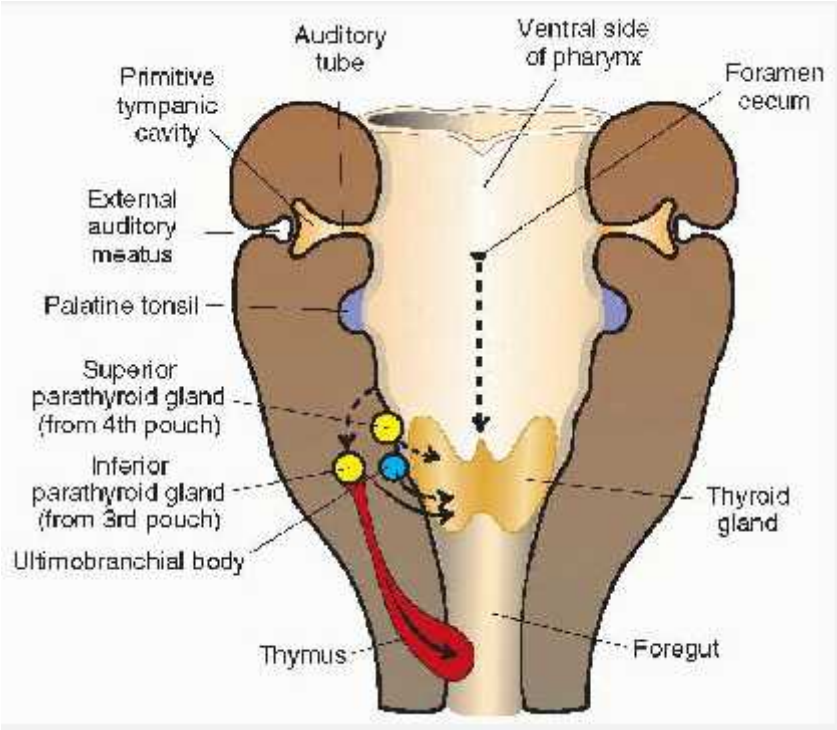


Fig 1[4] Migration of the thymus, parathyroid glands, and ultimobranchial body. The thyroid gland originates in the midline at the level of the foramen cecum and descends to the level of the first tracheal rings.

THYROID GLAND

The Germans call thyroid gland as "shield gland", the English word for thyroid gland is derived from Greek word thyreoeidos (Thyreos – sheild, eidos – from) with the same meaning.

It is related anterolaterally to cervical trachea, isthmus related to 2nd 3rd and 4th tracheal rings. Superiorly to inferior constrictor muscle and sternothyroid muscle and inferiorly to 5th-6th tracheal ring.Postero-laterally it crosssects the carotid sheath with contents. It weighs about 15–25 gm in adults.[5] Size of thyroid lobes is 4 cm superiorly to inferiorly, 15–20 mm in width and the thickness of 20–39 mm.[6-8]

Thin fibrous capsule covers the gland. A loose false capsule is formed by the deep cervical fascia which covers it laterally. Superficial fascia covers in anterior aspect and posteriorly it is by the berry's ligament.[5,12]

The berry's ligament attaches to inferior cornu of cricoid cartilage.[13]This ligament helps in thyroid elevation while deglutition.

The thyroid capsule is deficient in midline anteriorly because the fibres of "LevatorGlandulaeThyroideae (LGT)" which is a muscle extending from isthmus to hyoid. It occurs in incidence of0.49% to 58%. [14-17]

Tubercle of Zuckerkandl is enlargement on thyroid lobe on lateral edge. The RLN and superior parathyroid glands are in close relation to it. The RLN runs deep to this and this relationship can be varied if the tubercle is enlarged.[14]

Microscopically, thyroid gland is made of follicles, which in the euthyroid state consists of a monolayer of cuboidal or flattened epithelial cells (thyrocytes) surrounding a central lumen containing stored colloid. The follicles are loosely aggregated into lobules (thyromeres), each containing around 20–50 follicles separated by slender connective tissue septula.

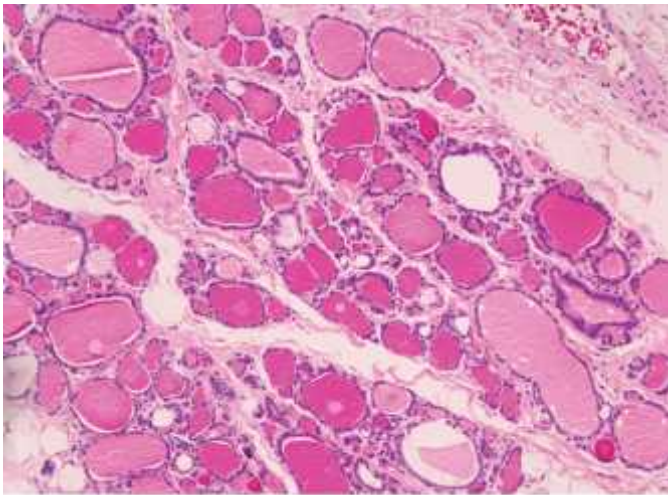


Fig 2[55] *Normal thyroid gland demonstrating a lobulararchitecture with uniform, round/ovoid follicles.*

PYRAMIDAL LOBE AND ISTHMUS

The pyramidal lobe (*Lalouette's lobe)* varies in size, extends superiorly from the isthmus of the thyroid gland, usually to the left of the median plane. The pyramidal lobe has a lot of variation. There may be a connection between apex of the pyramidal lobe to hyoid which is often a connective tissue band. These are formed from the remnants of thyroglossal duct (fig 3). The pyramidal lobe incidence can vary 15% and 75%.Two lobes of the thyroid is united by isthmus. It is situated in front of second and third tracheal rings and measures 20mm in width and length with thickness of 2-6mm.[1,18-23]

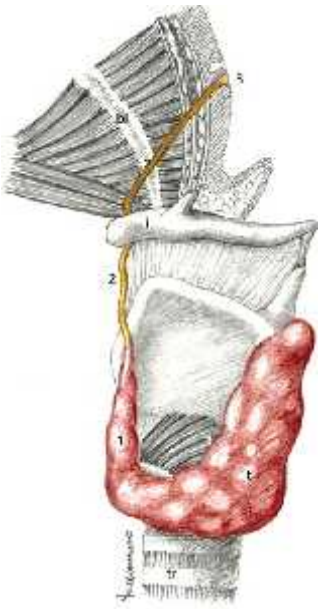


Fig 3[55]Thyroglossal duct and Lalouette's lobe

bl = tongue base i = hyoid bone t = thyroid gland tr = trachea 1 = Lalouette's lobe

2 = thyroglossal duct 3 = foramen cecum.

Anatomical variants of lobes of thyroid gland[1]

On basis of shape, thyroid is divided into 12 types (Fig. 5).

Type 1 (most frequent shape) - horseshoe shaped gland with a PYR-L.

Type 2- no PYR-L and shape of gland is horseshoe.

Type 3-separate lobes, with LGP arising from left part of hyoid extending caudally with bifurcation at the point of insertion to lobe.

Type 4- PYR-L on right

Type 5 -PYR-L on left

Type 6- PYR-L in middle

Type 7- ITA seperates gland into lobes.

Type 8- PYR-L is attached to hyoid.

Type 9, Type 10, Type 11 and Type 12- isthmus absent.

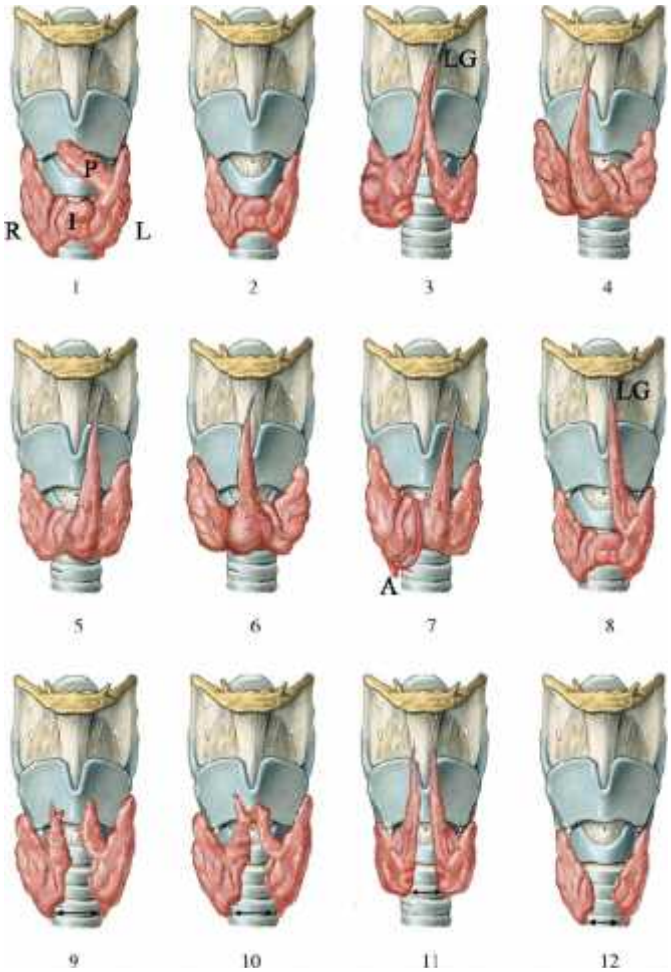


Fig.4[21]*Illustration of the classification of the thyroid gland shapes. 1 A pyramidal lobe (P) extending from the left side and crossing over the right side (type 1). 2 A horseshoe-shaped gland without a P (type 2). 3 A gland with two separate lobes: levatorglandulaethyroideae extends from the hyoid bone and bifurcates caudally to get attached to the fascia of each lobe (type 3). 4 A horseshoe shaped gland with a P extending to the thyrohyoid membrane on the right (type 4). 5 A horseshoe shaped gland with a P extending to the thyrohyoid membrane on the left (type 5). 6 A horseshoe shaped gland with a P extending to the thyrohyoid membrane in the middle (type 6) 7 The type in which inferior thyroid artery divides the gland into lobes (type 7). 8 A horseshoe-shaped gland with a P by LG extending to the hyoid bone (type 8). 9 Two separate lobes each extending as Ps (type 9). 10 Two PYR-Ls united cranially (type 10). 11 Two separate lobes each with two Ps extending to the hyoid bone (type 11). 12 A thyroid gland with two separate lateral lobes (type 12). R right lobe, L Left lobe, I isthmus, P pyramidal lobe, LG levatorglandulaethyroidea, A inferior thyroid artery, arrow separation*

VASCULAR STRUCTURE

The THY-GL recieves its blood supply mostly from STA and ITA. Sometimes, thyroideaima artery, a 3rd vessel is seen which replaces ITA & becomes principle artery supply to gland. The venous and lymphatic drainage of THY-GL is supported by "superior, middle and the inferior thyroid veins".[24]

ARTERIES SUPPLYING THYROID

Superior thyroid artery, which is initial branch from ECA arises close to CB. It lies superficial on inferior constrictor muscles of larynx, travels with superior thyroid vein and pierces the gland on posteromedial surface underneath the uppermost point of upper lobe.[21]It lies above external branch of superior laryngeal nerve at this point.[11]

It passes inferior to infrahyoid strap muscles, and subdivides into anterior and posterior branches at upper pole to supply their respective surfaces of lobes. Just before branching at superior pole, each artery branches into superior laryngeal artery that travels across thyrohyoid membrane with superior laryngeal nerve to enter larynx, and a cricothyroid artery which lies on cricothyroid membrane near inferior border of thyroid cartilage.[5,25]

The three major branches of STA are sternocleidomastoid branch, ventral medial and dorsal lateral branches. The ventral medial branch being larger, communicates through isthmus with branches from contralateral gland, while dorsal lateral branch interconnects with branches from inferior thyroid artery on the same side.[3]

Inferior thyroid artery originates as a division from thyrocervical trunk, which arises out of first part subclavian artery. It progresses superiorly along anterior scalene muscle, turns medially traveling behind carotid sheath with variable relationship to

the sympathetic chain.It then turns sharply and drops away on posterior surface of the lateral lobes where it forms two branches before entering inferior pole. [4]

Inferior thyroid artery branches supply the thyroid as well as to upper esophagus, trachea and the parathyroid glands.[6] After branching into anterior and posterior branches, the association of recurrent laryngeal nerve with inferior thyroid artery may be quite variable.

Thyroidea-ima artery is an inconsistent branch in the arterial supply to thyroid gland. It has a variable origin and may arise from the aortic arch, subclavian, brachiocephalic trunk, CCA, or the internal thoracic arteries.[26]It sometimes replaces inferior thyroid artery which develops into main arterial supply to gland.[5] It courses superiorly anterior to trachea to supply gland near midline and for this reason, it is in possibility of injury during tracheostomy.

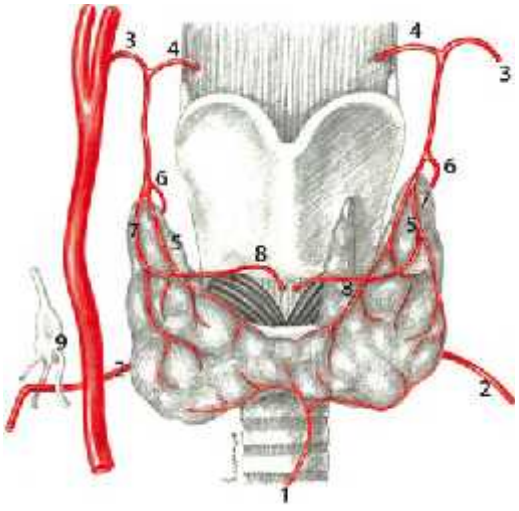


Fig. 5[55]*Thyroid vascular pedicles 1 = ima thyroid artery 2 = inferior thyroid artery 3 = superior thyroid artery*

4 = superior laryngeal artery 5 = superior thyroid artery (medial branch) 6 = superior thyroid artery (posterior branch) 7 = superior thyroid artery (lateral

branch) 8 = cricothyroid artery 9 = middle cervical ganglion (sympathetic cervical chain)

VENOUS SUPPLY

A dense network of connecting vessels is present within the thyroid capsule. The veins which drains the capillary plexuses forms "inferior, middle and superior thyroid veins" which meets the IJV and "innominate veins".[24]

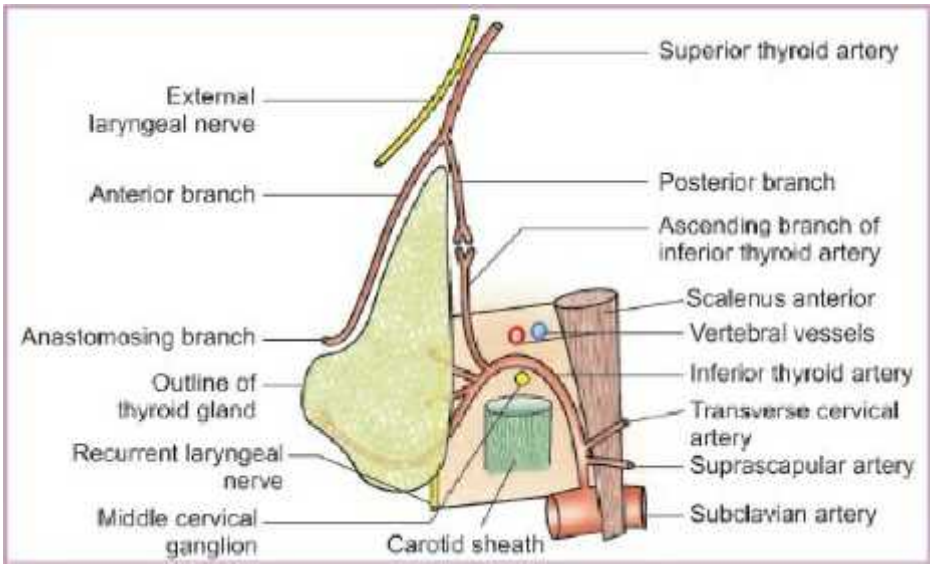


Fig 6[28] Arterial supply of the thyroid gland (lateral view).

Superior thyroid artery- its origin and variations

The STA is first branch from anterior wall of ECA, it can also arise near the level CB or also from CCA. The STA normally rises ECA just inferior to level of hyoid.[3] Most common (40%) location of origin of STA is from level of CB and origin from ECA is 25% & CCA is 35%.[3,27]

The STA can arise from linguofacial trunk, from thyrolingual trunk, or independently.

Branches of STA[3]

There are five branches of the STA: the infrahyoid, sternocleidomastoid, superior laryngeal artery, cricothyroid, and terminal branches of the artery for the blood supply of parathyroid glands and thyroid glands.

The branching pattern of the STA are classified into six categories.

Type1 the infrahyoid branch and SLA were divided, followed by the sternocleidomastoid artery and the glandular thyroid branch.

Type 2 the infrahyoid branch was divided and then the three branches (superior laryngeal, thyroid glandular and sternocleidomastoid branches) were divided at one point.

Type 3 the infrahyoid branch was divided first and then the sternocleidomastoid artery was divided

second from the STA, followed by the SLA and the thyroid glandular branch.

Type 4 the SLA was originated from the ECA and the sternocleidomastoid artery arose from the SLA.

Type 5 the infrahyoid branch was originated from the ECA and the SLA was divided first and then the sternocleidomastoid artery was divided second from the STA, followed by the thyroid glandular branch.

Type 6 the sternocleidomastoid branch was divided from the ECA and infrahyoid branch was divided first and then the SLA was divided second from the STA, followed by the thyroid glandular branch.

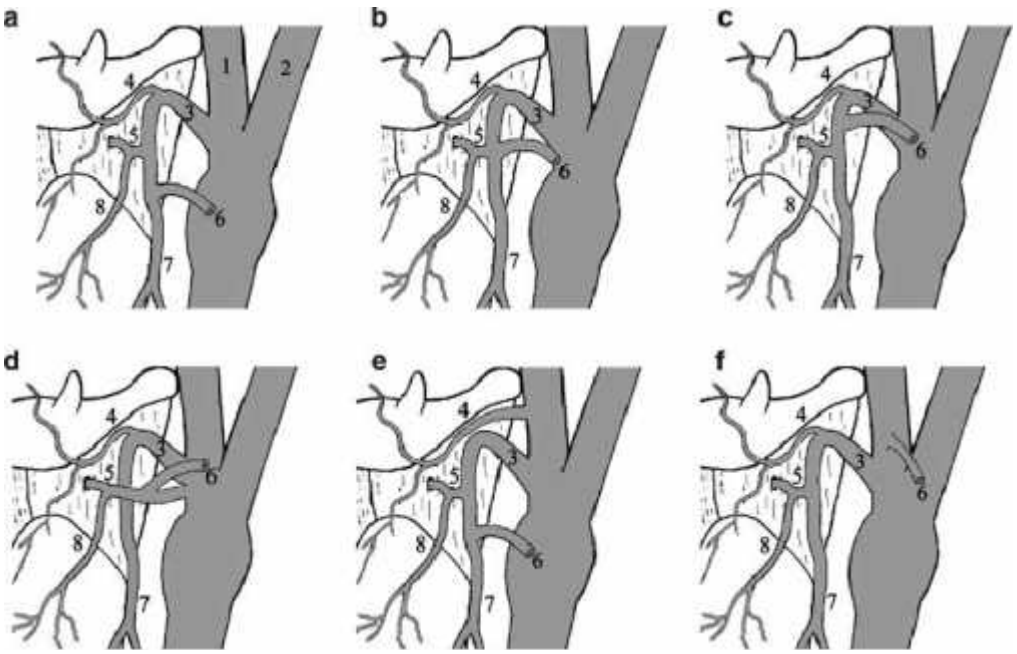


Fig.7[3]The branching types of the superior thyroid artery. 1 external carotid artery, 2 internal carotid artery, 3 superior thyroid artery, 4 infrahyoid branch, 5 superior laryngeal artery, 6 sternocleidomastoid branch, 7 anterior glandular branch, 8 cricothyroid branch

NERVES ASSOCIATED WITH THYROID GLAND

EMBRYOLOGIC CONSIDERATIONS

The anatomy of vagus nerve was described by Vesalius and Willis in 16th and 17th centuries.[29] The cervical branches of vagus that are relevant to thyroid surgery are recurrent laryngeal nerve & superior laryngeal nerves.

The vagus nerve originates from medulla oblongata and leaves skull through pars nervosa of jugular foramen.[30]Just below this is the take off point of SLN.

The vagus descends in carotid sheath in neck firstly at a location medial to IJV then at a posterior position inferiorly between ICA and IJV. RLN arise as vagus courses anteriorly to aortic arches.[30]

On right side, RLN recurs around 4th arch which is right subclavian artery, on left, RLN recurs around 6th arch which is ligamentum arteriosum.[4]

RECURRENT LARYNGEAL NERVE

The RLN innervates intrinsic musculature of larynx and provides sensory supply to glottic area of larynx. On the left RLN arises from vagus when it crosses arch of aorta. It then loops around aorta to climb in tracheoesophageal groove behind THY-GL to enter the larynx.[31,32] RLN on right side originates from vagus when it crosses right subclavian artery in front. It then circles around artery and climbs in tracheo-esophageal groove, to enter larynx behind cricothyroid articulation and inferior cornu of thyroid cartilage behind THY-GL.[11,33,35] Approximate length of left RLN from cricothyroid joint to aorta is around 12 cm, while the length of right RLN from cricothyroid joint to subclavian artery is about 5–6 cm.[36]

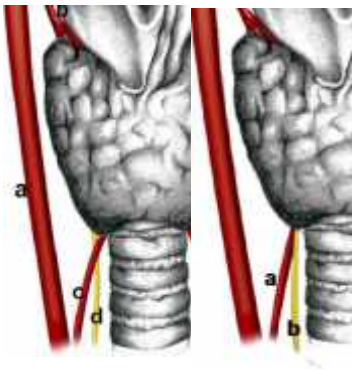
The left RLN is more closely associated to trachea in the inferior part of its ascending course than is the right nerve.The nerve runs at a slight angle across the trachea-esophageal groove and then becomes parallel and closely applied to trachea. During the middle course, the nerve is found within tracheoesophageal groove in about half of thepopulationit may be found anterior or posterior to the groove (within suspensory ligament of Berry, anterolateral to trachea in substance of thyroid gland, or lateral to esophagus). [31-33]

RLN enters larynx deep to muscle fibres of inferior constrictor and next to cricothyroid joint.[37] The nerve breaks into external branch providing motor function to intrinsic laryngeal muscles other than cricothyroid muscle and internal branch supplying sensation to vocal cords and subglottic region. An ascending branch of RLN anastomoses with a division of SLN to form Galen anastomosis. Branches from this anastomosis pierce transverse arytenoid muscle to reach the mucosa of posterior laryngeal wall. [38,39]

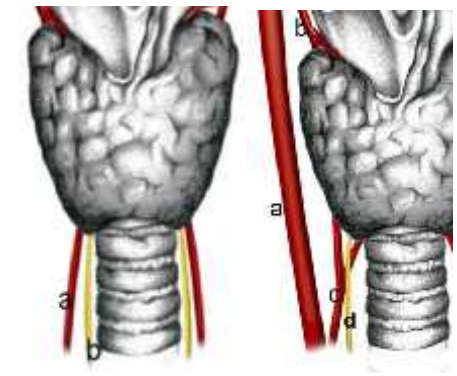
The RLN in the neck is supplied by branches of ITA that supply parts of trachea and esophagus. The distal part of RLN is supplied by branch of inferior laryngeal artery which itself is branch of ITA.[25] The variable association of RLN to TE groove, ligament of Berry, and ITA is described further. The nerve largely passes posterior to middle thyroid vein.[39,40]

Relationship of RLN to inferior thyroid artery

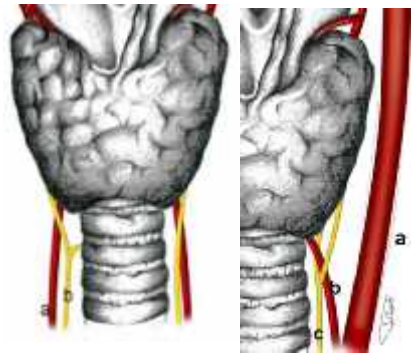
RLN ascend toward the middle of THY-GL, they are closely associated with ITA. Multiple variations have been explained in relationship of nerve to ITA and the branches. The 3 basic configurations include nerve anterior to the artery, nerve between branches of the artery, and nerve posterior to the artery. [31-33]



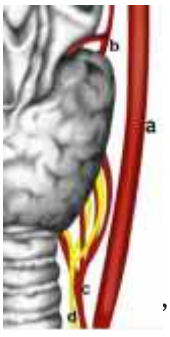
Type 1; The RLN lay posterior to the artery, a: CCA, b: STA, c: ITA, d: RLN
Type 2; The RLN lay anterior to the artery,a: ITA, b: RLN.



Type 3; The RLN lay parallel to the artery, a: ITA, b: RLN. Type 4; The RLN lay between two branches of the artery, a: CCA b: STA, c: ITA, d: RLN.



Type 5; Theextralaryngeal branch of the RLN was detected before it crossed the ITA, a: ITA, b: RLN. Type 6; The ITA lay between two branches of the RLN, a: CCA, b: ITA, c: RLN.



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Type 7 The branches of the RLN lay among the branches of ITA, a: CCA, b: STA, c: ITA, d: RLN

Fig 8[41] Variations in relationship of recurrent laryngeal nerve and inferior thyroid artery

Association of RLN to LB

LB anchors thyroid gland to laryngotracheal complex and forms a surgically important medial relation of the RLN as it loops to enter the larynx. [12] The relationship of RLN and Berry ligament has been observed as dorsolateral to ligament.Variations seen are the RLN is said to be medial to, lateral to, or embedded in lateral LB. In majority of the cases the RLN is embedded in suspensory LB and the nerves may be pulled forward and are therefore vulnerable to injury during glandular traction. [35]

THE ZUKERKANDL'S TUBERCLE

It is most protuberant area of the postero-lateral margin of the thyroid. Emil Zukerkandl named it in 1902. The Zuckerkandl's tubercle is an "embryologic fusion of ultimobranchial body and median thyroid process" and forms a milestone for RLN in thyroid surgery. The ZT is an significant anatomical landmark in thyroid surgeries owing to its association with RLN and SP.[42,43]

Grades of the ZT[42]

Grade 0- unrecognizable

Grade 1- <5mm

Grade 2- 6-10mm

Grade 3- >10mm

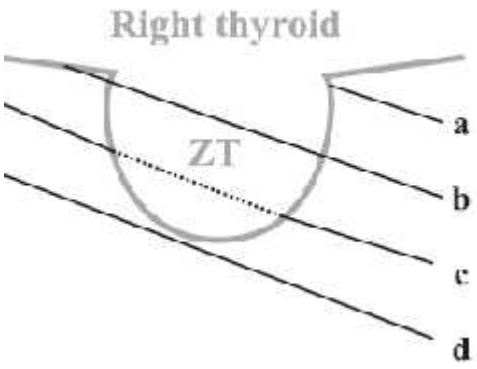


Fig 9[43] Relationship of ZT with RLN

Type A- posterior ZT surface

Type B- anterior ZT surface

Type C- passing through ZT parenchyma

Type D- lateral of ZT

D1- attached to apex of the ZT

D2- departing from apex of the ZT

Relationship of ZT with SP[43]

The SP is usually located in the upper portion behind the RLN and inferior thyroid artery

SUPERIOR LARYNGEAL NERVE

SLN is one of the first branches of vagus separating at the nodose descending posteriorly and medial to the carotid sheath. SLN has internal and external branches.[30]

External branch of superior laryngeal nerve (EBSLN) supplies cricothyroid muscle and mucous membrane of lower part of larynx. It has variable course along the branches of superior thyroid artery. It curves anteriorly and medially close to the lower edge of the thyroid cartilage before innervating of the cricothyroid muscle.[46-51]

4 types have been observed between EBSLN and THY-GL (upper pole) and STA.[46,51]

Type 1- EBSLN intersect STA >1 cm above upper pole of thyroid

Type 2- EBSLN intersect STA < 1 cm of the upper pole

Type 3- EBSLN intersect STA immediately above thyroid gland upper pole.

Type 4- EBSLN not cross STA, but runs dorsal to the artery before it ramifies.

Internal branch of superior laryngeal nerve (IBSLN) gives sensory supply to laryngeal mucosa after penetrating the thyrohyoid membrane.[52,53]

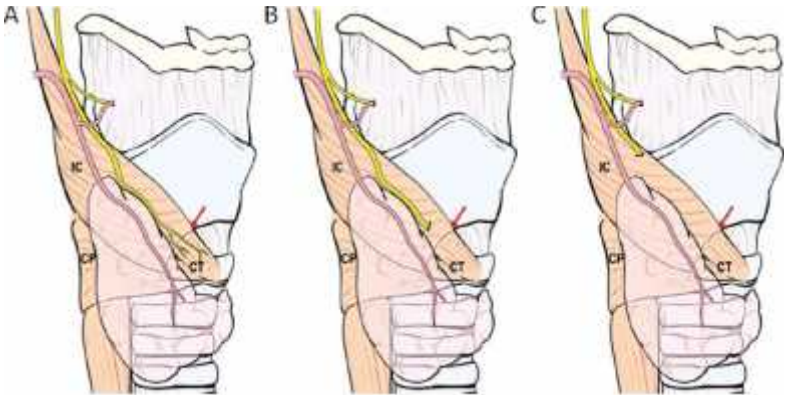


Fig.10[24] The variation in the course of the external branch of the superior laryngeal nerve with respect to the superior thyroid artery and superior thyroid pole. A: The EBSLN descends superficial to the inferior constrictor muscle (IC) along with the superior thyroid vessels and is visible in its entire course before innervating the cricothyroid (CT) muscle. B: The EBSLN pierces the IC muscle about 1 cm above the

CT membrane (arrow). C: The EBSLN runs deep to the IC muscle and is protected. CP marks the cricopharyngeus muscle

Common landmarks for identification of nerves[57]

1. Beahrs Triangle or *Riddle's triangle*

This triangle is named after OH Beahrs. Also, synonym with Riddle's triangle. The nerve is identified down in tracheo-oesophageal groove. The nerve forms third side of Beahr's triangle. The other two sides are by the common carotid and inferior thyroid arteries.

2. Joll's Triangle

Synonym is sternothyrolaryngeal triangle.

This is used to identify external branch of superior laryngeal nerve which lies within this triangle. Upper pole of thyroid gland and superior thyroid vessels forms the Lateral border.

Superiorly- Attachment of the strap muscles, Medial the landmark is the Midline, Floor is formed by Cricothyroid muscle.

3. Simon's triangle: This another triangle described to identify the RLN.

Anterior border is formed by the RLN, posterior by the common carotid artery and base is formed by the inferior thyroid artery

4. Lore's Triangle

Described by Lore et al., to identify the RLN. Medial border is by the trachea / esophagus, laterally the carotid artery and superiorly the surface of inferior pole of thyroid.

5. Triangle of concern

The sites of bleeding during thyroidectomy are middle thyroid veins, ITV and branches of ITA in the vicinity of RLN.

6. Cricothyroid space of reeves

This is an avascular space between the upper pole of the thyroid and the cricothyroid muscle which is useful in dissection and helps in avoiding injury to the surrounding important structures like the superior laryngeal nerve.

PARATHYROID GLANDS

Endoderm of 3rd and 4th pharyngeal pouches give rise to parathyroid glands. A total of 4 parathyroid glands are present. Incidence of supernumerary glands is 13% and upto 11 glands was seen in large autopsy series.[59]These are shaped like that of a leaf, yellow or mahogany in color. The weight of the gland is about 35 to 40 mg, size is 3-8 mm. Inferior thyroid artery supplies both upper and lower parathyroid glands in 76%-86% cases. [60-64]

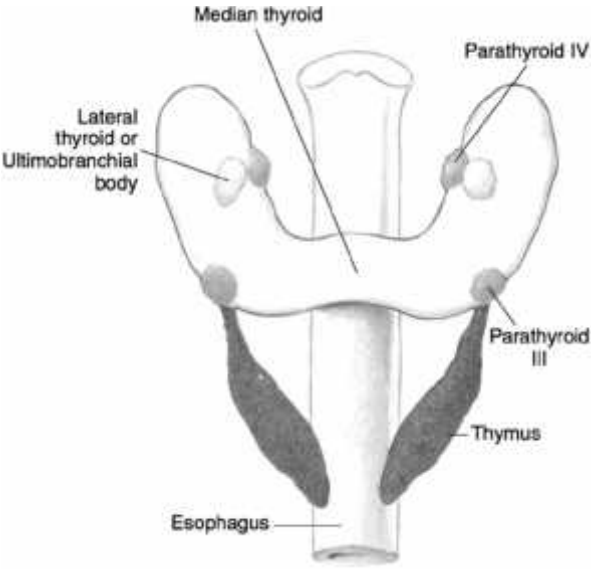


Fig 11[62] A schematic representation depicting the locations of the thyroid, lateral thyroid, thymus, and parathyroid glands. During embryological development, the parathyroid III and the para- thyroid IV migrate together with the thymus and ultimobranchial bodies, respectively.

It contains two types of cells - chief and oxyphil cells. Parathyroid hormone (PTH) is secreted by chief cells which are small and are seen as pale cells on eosin stain.

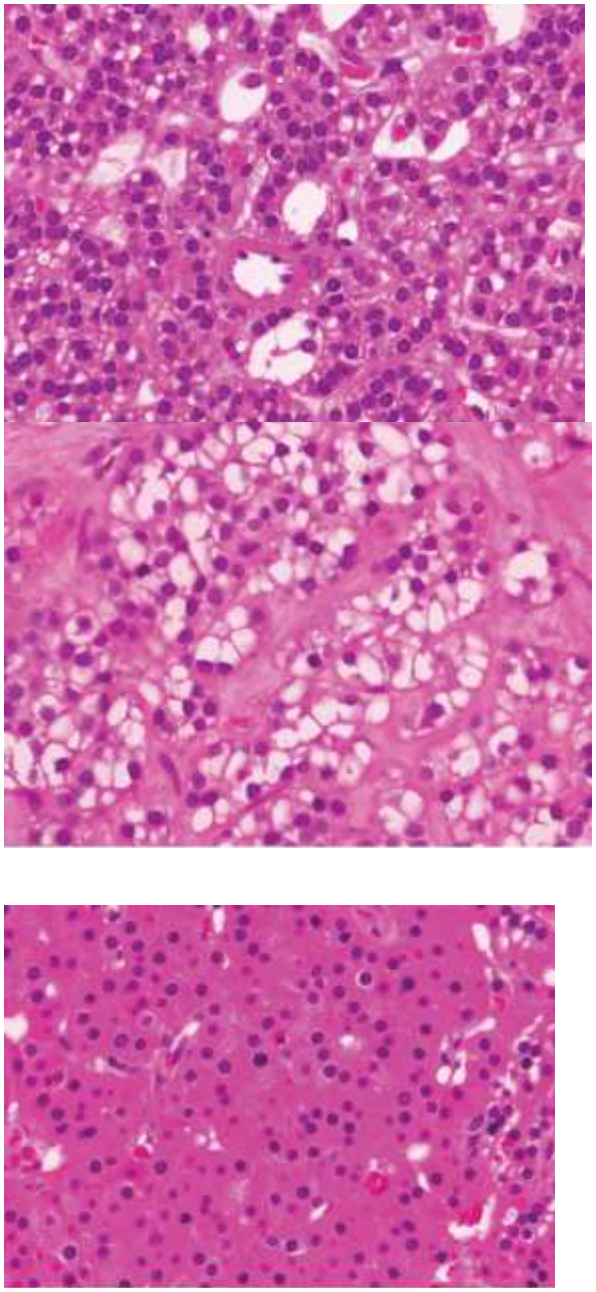


Fig 12[56] Normal parathyroid glands. (a) Nests and trabecula of isomorphic chief cells forming occasional glandular lumina or so-called microfollicular/pseudofollicular growth pattern (H&E stain, high magnification). (b) Clusters of water-clear cells displaying their characteristic clear, generally univacuolar cytoplasm with eccentrically displaced nuclei (H&E stain,high magnification). (c) Nodular sheets of

oncocytic (oxyphil) cells illustrating their hallmark, copious, granular and densely eosinophilic cytoplasm, attributable to plentiful mitochondria. A minor degree of random nuclear pleomorphism is often encountered (H&E stain, high magnification).

SUPERIOR PARA THYROID GLANDS

Superior parathyroid glands are located in posterolateral side of thyroid lobes.[4,63] It is situated near the cricothyroid membrane, about 1cm above RLN and inferior thyroid artery connection.

Other locations of superior para thyroid glands

Varied locations of the gland are rarely seen and is due to failure of descent or lateral descent.[24] Other locations comprise the tracheoesophageal groove, posterior mediastinum, retroesophageal, and retropharyngeal positions in the carotid sheath or intra thyroidal locations. [61] The intra thyroidal location occurs from the unusual migration, also the superior glands sometimes join ultimobranchial body because it merges with the median thyroid.[59,66]

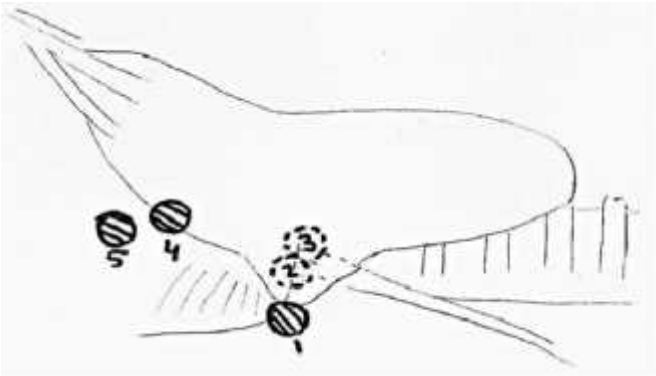


Figure 13[62]: *Location of superior parathyroid glands.*

Abbreviations: *TZ: Tubercle of Zuckerkandl; RLN: Recurrent Laryngeal Nerve; 1: At or just cranial to TZ; 2: Overlying RLN; 3: Low down on deep surface of thyroid,*

medial to RLN (not seen from above during mobilization of upper pole); 4: Deep surface of thyroid (seen from above during mobilization of upper pole); 5: Away from deep surface of thyroid

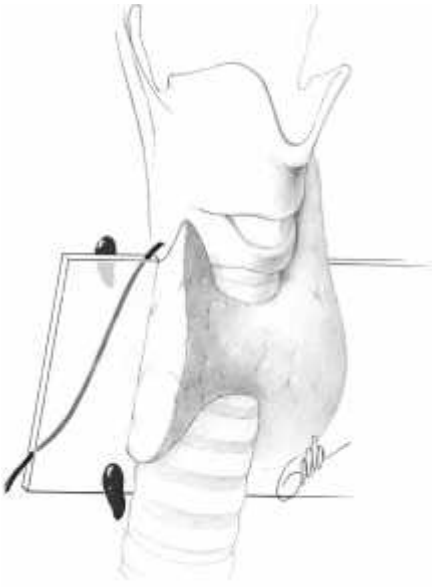


Fig 14[62]The parathyroid glands and their anatomic relation to the RLN coronal plane in the neck. The superior parathyroid glands lie dorsal(deep)and the inferior parathyroid glands lie ventral (superficial) to the RLN plane [62]

INFERIOR PARA THYROID GLANDS

They originate from 3rd pharyngeal pouch and travel along "thymus" in medial and caudal direction.[4,67] This accounts for variable adult position than superior glands lies ventral to superior parathyroid glands.

They are located on the postero-lateral part of the capsule of inferior pole or within 1-2cm. They are usually located superficial to the RLN.[63]

Other locations of inferior para-thyroid glands

They can be located alongside the course of its descent to upper edge of pericardium.[68]The varied location of gland is due to failure of its descent with thymus which results in location near CB and embedded in an ectopic thymic remnant. [59,69] Incidence of not descending of parathyroid glands is seen in 2%.[61,70] Inferior parathyroid glands can be located close to anterior superior mediastinum closely to thymic fragments. Intrathyroidalparathyroidal glands may be PIII or PIV; even supernumerary glands can be intrathyroidal. [71-73]

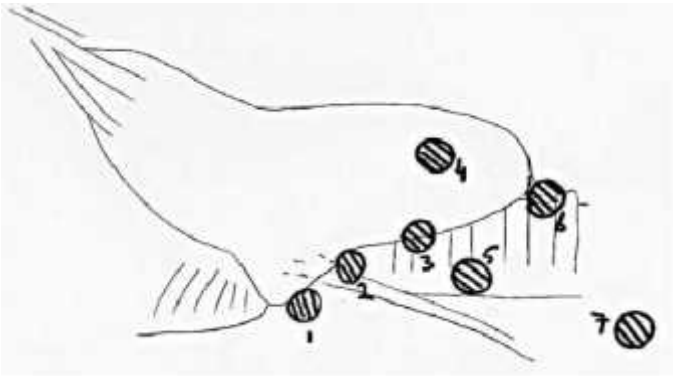


Figure 15[62]: *Location of inferior parathyroid glands.*

Abbreviations: *TZ: Tubercle of Zuckerkandl; RLN: Recurrent Laryngeal Nerve; 1: At or just caudad to TZ; 2: Overlying RLN; 3: Deeply located on lateral surface of*

thyroid; 4: Superficially located on lateral surface of thyroid; 5: Deeply located, away from lower lateral surface of thyroid; 6: Thyrothymic ligament; 7: Superior mediastinum

ZuhalOzgur of turkey in 2011 studied lobes of thyroid gland and types come about with 60% frequency for occurrence of PYR-L, isthmus in 77.5% and 12% for separate lobes. Existence of pyramidal lobe and levatorglandulaethyroideae and separate lobes cause variations of vascular supply of lobes.of thyroid.[1]

Ozgur et al in 2008 reported that STA arose from ECA 25% of the time, from CB 40% and from CCA 35%. He also classified STA into six categories based on branching patterns.[3]

Sung- Yoon Won of Korea in 2016 studied anatomical descriptions of overall anatomy of STA, its relationship to other structures and its driving patterns and found out in 83.3% Superior Thyroid, Lingual, Facial arteries arise independently from the ECA, but in 16.7% of cases arose together as thyrolingual or lingulofacial trunk.[74]

Kaisha et al of Kenya in 2011 observed the Recurrent Laryngeal Nerve stood anterior to the Inferior Thyroid Artery in 37% of cases and in 51.4% it was found to be posterior to ITA. With Ligament of Berry, 45.3% RLN was superficial and to Zukerkandl Tubercle, it was medial to it in 54.7% cases.[75]

Antonius C. Kierner,MD; Martin Aigner,MD; Martin Burim,MD of Vienna in 1998 categorised the varied location of EBSLN to facilitate identification of nerve during surgery. He found Type 1 i.e EBSLN crosses the STA more than 1 cm cranial to upper pole of the trunk thyroid gland, Type 2 EBSLN crosses the STA less than 1cm cranial to upper pole, Type 3 EBSLN crosses the STA very close to upper pole, Type 4 EBSLN does not intersect the trunk. [46]

Hojaji et al in 2011 studied and reported important information for surgeons to localize parathyroid. Gland identity was confirmed by histological study.[71]

MATERIALS AND METHODS

This study involved neck dissection in total 40 fresh frozen cadavers at Department of Anatomy, of KAHER'S Jawaharlal Nehru Medical College, Belagavi, during the study period.

Study Design: Observational study

Study Period: 1year [January 2019- December 2019]

Sample Size:40 fresh frozen cadavers

Sample size formula:The minimum sample size formula based on mean and standard deviation isn = $\frac{(z_\alpha + z_\beta)^2(s_1^2 + s_2^2)}{(\overline{X}_1 - \overline{X}_2)^2}$

where z_α is linked with the level of significance and z_β islinked with the power of the test. For 5% level of the significance z_α =1.96 and z_β =0.84 for 80% power of the test. $\overline{X}_1$ is the mean of the first group (8.9) and $\overline{X}_2$ is the mean of the second group (12.0). s_1 is the standard deviation of the first group (4.4) and s_2 is the standard deviation of the second group (5.5).

With these values the sample size obtained is 40.

Ethical Clearance– Obtained from the Institutional Ethical Committee

Selection criteria

Inclusion Criteria:

1. All the fresh frozen cadavers available at department of Anatomy during the study period

Exclusion criteria:-

1. Cadavers who had history of trauma or surgical procedures around neck region
2. Evidence of neck deformities and neck tumors

Methodology:

- A midline incision extending from mentum to manubrium was given. Infrahyoid muscles identified and cut. Fascia from the Thyroid gland removed to expose arteries and veins. Then their branching pattern was observed. After lifting the lower part of the gland, the recurrent laryngeal nerve identified in groove between trachea and oesophagus.
- THY-GL shapes and morphology and distance of surrounding structures was measured with digital calipers sensitive to 0.01 mm.
- The course and origin of superior thyroid artery was studied. Latex was injected into the CCA to permit observation of topographic relationship of STA. With the use of digital calipers the position of superior thyroid artery related to known landmarks like muscles, cartilage and surrounding structures was measured and classified.
- Topography of RLN related to ITA, LB, Zukerkandl's tubercle was studied.
- EBSLN and its relation to STA was studied.
- Anatomical distribution of parathyroid gland was studied and gland identity was confirmed by histology using hematoxylin and eosin stain. The thyroid gland was divided to identify parathyroid in parenchymal and subcapsular space.
- Data collection included morphometric details and anatomical distribution and variations of both the sides of thyroid gland and its surrounding relations.

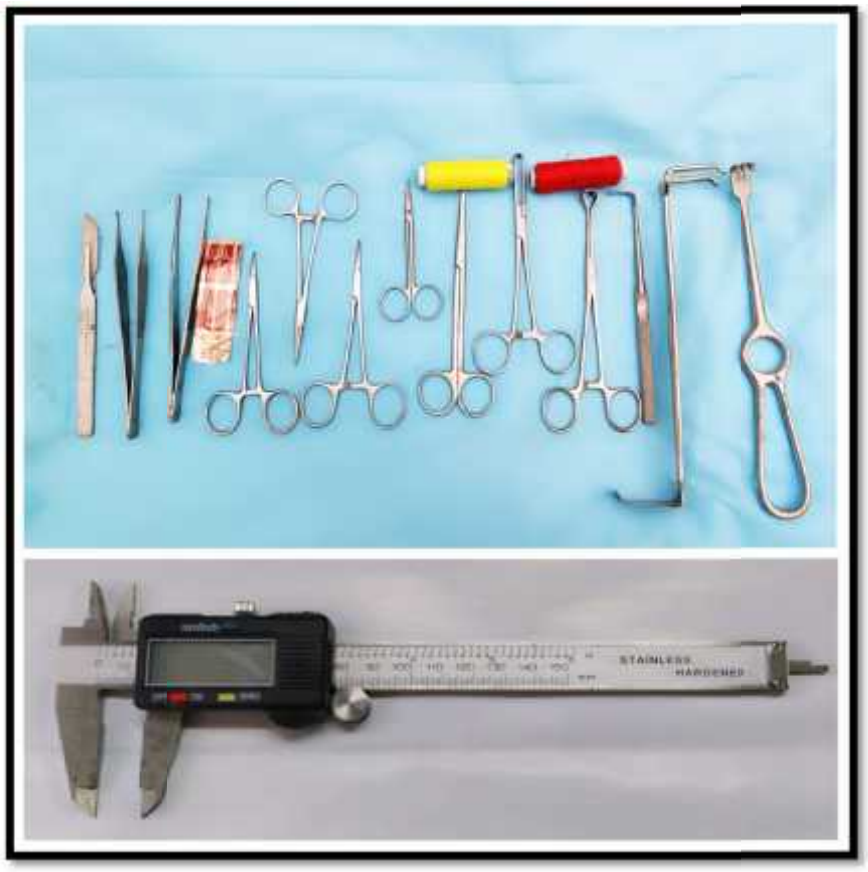


Image 1: Instruments

RESULTS

Forty fresh frozen cadavers of different geographic areas of India and of both the genders available in department of Anatomy of KAHER's Jawaharlal Nehru Medical College from January 2019 to December 2019 were studied on morphometric details, anatomical distribution and variations of thyroid gland and its surrounding relations.All observations recorded in the study are described under the following headings.

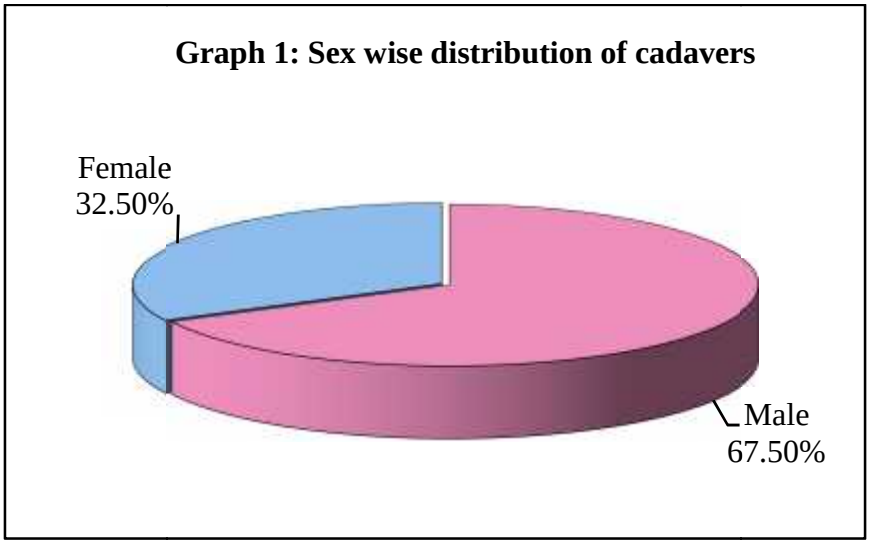
Sex distribution-

Out of 40 cadavers, 27(67.50%) were male and 13(32.50%) were female. The sex distribution is depicted below.(Table 1, Graph 1)

Table 1: Sex wise distribution of cadavers

Sex	No of cadavers	% of cadavers
Male	27	67.50
Female	13	32.50
Total	40	100.00

Graph 1: Sex wise distribution of cadavers



Age wise distribution of cadavers

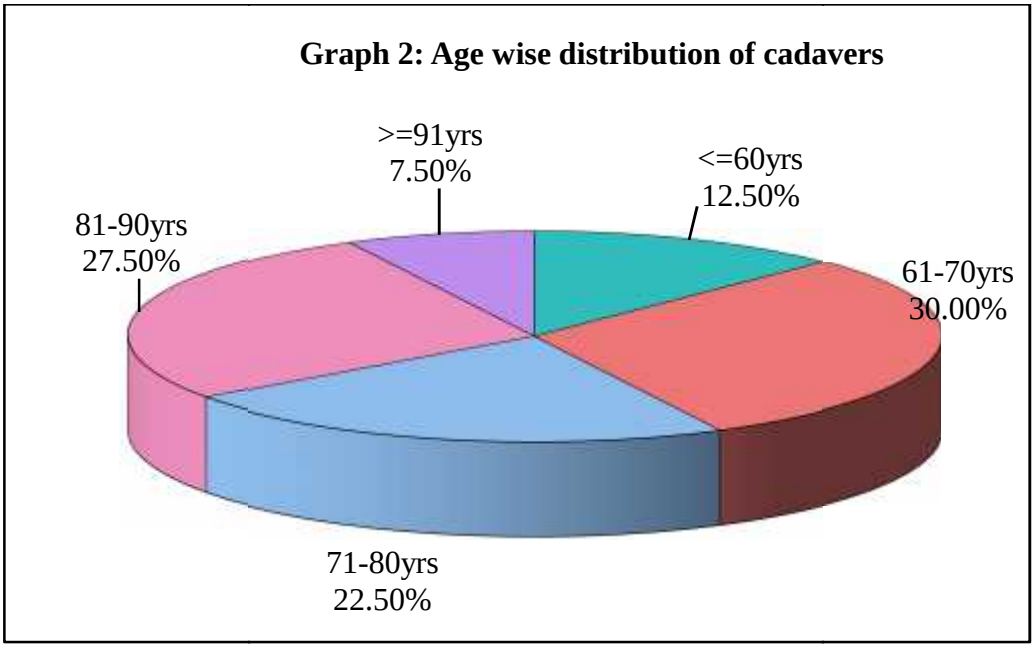
The cadavers were distributed according to their age into categories. Out of the 40 cadavers, the groups were formed as <=60 years, which had 5 cadavers (12.50%), 61-70 years had 12 cadavers (30.00%), 71-80 years had 9 cadavers (22.50%), 81-90 years group had 11 cadavers (27.50%), >=90 years had 3(7.50) cadavers.

The Mean Deviation is 73.98 and Standard Deviation is 12.53. The data is depicted below. (Table 2, Graph 2)

Table 2: Age wise distribution of cadavers

Age groups	No of cadavers	% of cadavers
<=60yrs	5	12.50
61-70yrs	12	30.00
71-80yrs	9	22.50
81-90yrs	11	27.50
>=91yrs	3	7.50
Total	40	100.00
Mean	73.98	
SD	12.53	

Graph 2: Age wise distribution of cadavers



Lobes of thyroid gland-

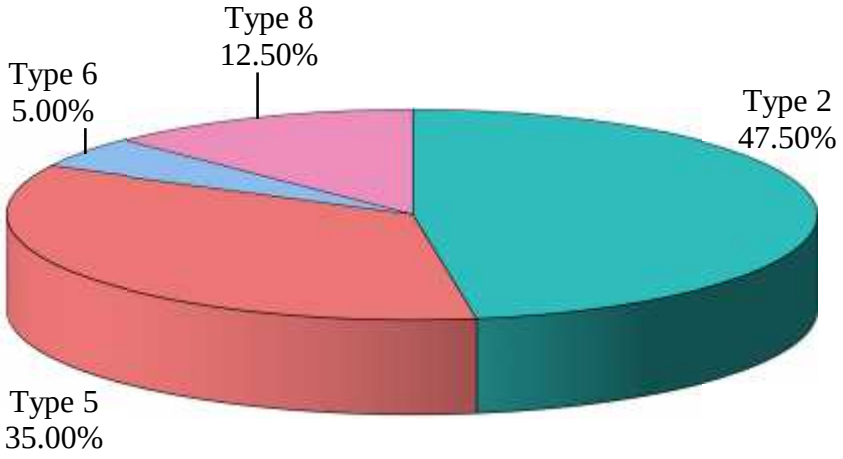
"Type 2 was found to be the most frequent shape in this study. It consisted of the horseshoe-shaped gland without a pyramidal lobe (PYR-L) and was seen in 19 specimens (47.5%). The second most frequent, type 5 the PYR-L was placed on the left was seen in 14 specimens (35%)."

2 specimens (5%) had type 6 where the PYR-L was placed in middle and type 8 where the PYR-L was attached to hyoid with the (LGT) was seen in 5 specimens (12.50%).

Table 3: Types of lobes of thyroid gland

Types of lobes of thyroid gland	No of cadavers	% of cadavers
Type 2	19	47.50
Type 5	14	35.00
Type 6	2	5.00
Type 8	5	12.50
Total	40	100.00

Graph 3: Types of lobes of thyroid gland



Distance of origin of STA to surrounding structures

Out of 80 cadaver samples, right and left sides, the distance from origin of STA to the CB was 3.08 ± 1.88 mm, with minimum distance of 0.2mm and maximum of 6.40mm.

The STA origin distance to lingual artery was 7.80 ± 2.11 mm, to facial artery was 14.73 ± 3.00 mm. distance to superior laryngeal nerve was 8.42 ± 1.33 mm.

The distance from STA to hypoglossal nerve was 18.35 ± 2.27 mm and to upper edge of TC was 4.52 ± 1.94.

The data of minimum and maximum distances along with mean and standard deviation of various surrounding structures to origin of STA is depicted below (Table 4 and 5, Graph 4)

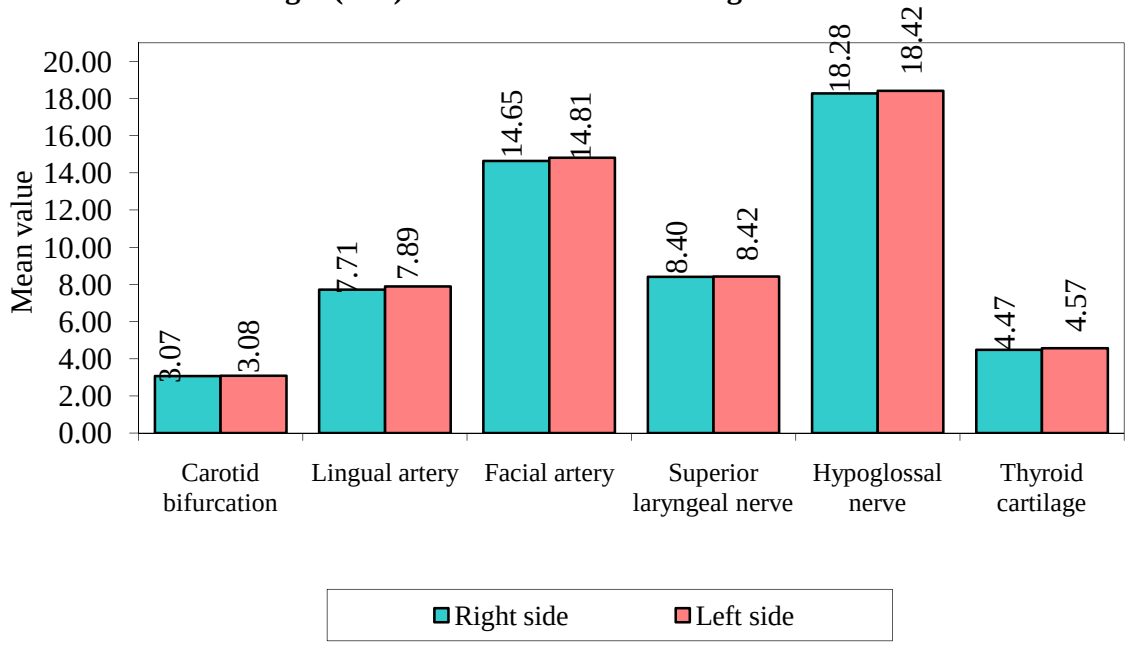
Table 4: Summary of distance of origin (mm) of STA on right and left sides

Distance of origin (mm) in	Sides	N	Min	Max	Mean	SD	SE	95% CI for mean	
								Lower Bound	Upper Bound
Carotid bifurcation	Right	40	0.20	6.40	3.08	1.86	0.29	2.48	3.67
	Left	40	0.20	6.40	3.08	1.93	0.31	2.46	3.69
	Total	80	0.20	6.40	3.08	1.88	0.21	2.66	3.49
Lingual artery	Right	40	5.40	15.10	7.71	2.08	0.33	7.04	8.37
	Left	40	5.20	15.40	7.89	2.16	0.34	7.20	8.58
	Total	80	5.20	15.40	7.80	2.11	0.24	7.33	8.27
Facial artery	Right	40	7.80	18.50	14.65	3.03	0.48	13.68	15.62
	Left	40	8.00	18.40	14.81	3.01	0.48	13.85	15.77
	Total	80	7.80	18.50	14.73	3.00	0.34	14.06	15.40
Superior laryngeal nerve	Right	40	4.20	11.40	8.41	1.39	0.22	7.96	8.85
	Left	40	4.40	11.60	8.43	1.30	0.20	8.01	8.84
	Total	80	4.20	11.60	8.42	1.33	0.15	8.12	8.71
Hypoglossal nerve	Right	40	9.20	22.10	18.28	2.32	0.37	17.54	19.02
	Left	40	9.90	22.20	18.42	2.23	0.35	17.71	19.14
	Total	80	9.20	22.20	18.35	2.27	0.25	17.85	18.86
Thyroid cartilage	Right	40	1.00	7.20	4.47	1.93	0.31	3.85	5.09
	Left	40	1.40	7.40	4.57	1.97	0.31	3.93	5.20
	Total	80	1.00	7.40	4.52	1.94	0.22	4.08	4.95

Table 5: Comparison of right and left sides with mean distance of origin (mm) of STA with surrounding structures by independent t test

Distance of origin (mm) in	Right side		Left side		t-value	p-value
	Mean	SD	Mean	SD		
Carotid bifurcation	3.07	1.86	3.08	1.93	-0.0018	0.9986
Lingual artery	7.71	2.08	7.89	2.16	-0.3947	0.6941
Facial artery	14.65	3.03	14.81	3.01	-0.2446	0.8074
Superior laryngeal nerve	8.40	1.39	8.42	1.30	-0.0684	0.9457
Hypoglossal nerve	18.28	2.33	18.42	2.23	-0.2813	0.7793
Thyroid cartilage	4.47	1.93	4.57	1.97	-0.2268	0.8212

Graph 4:Comparison of right and left sides with mean distance of origin (mm) of STA with surrounding structures



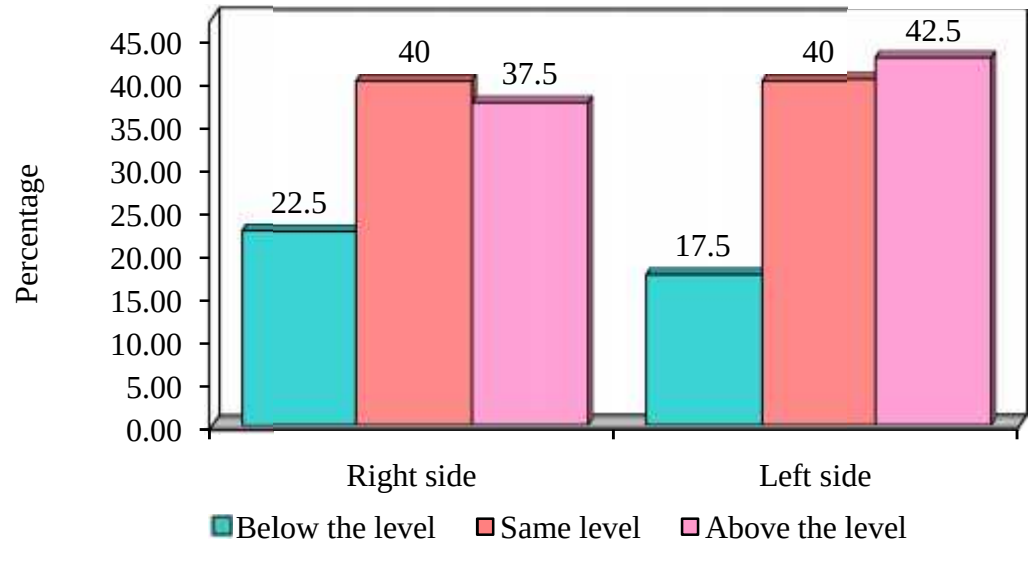
Origin of STA in relation to carotid bifurcation

Out of 80 cadaver samples, right and left sides, in 16 sides STA arose from below the level of the bifurcation, 32 arose from same level of carotid bifurcation and 32 from above the level of carotid bifurcation. Comparison between left and right sides have been shown below. There was no significant difference with P value >0.01. (Table 6, Graph 5)

Table 6: Comparison of right and left sides with status of origin of STA in relation to carotid bifurcation

Origin in relation to level of carotid bifurcation	Right side	%	Left side	%	Total	%
Below the level	9	22.50	7	17.50	16	20.00
Same level	16	40.00	16	40.00	32	40.00
Above the level	15	37.50	17	42.50	32	40.00
Total	40	100.00	40	100.00	80	100.00
Chi-square= 0.3752 P = 0.8290						

Graph 5: Comparison of right and left sides with status of origin of STA in relation to Carotid bifurcation



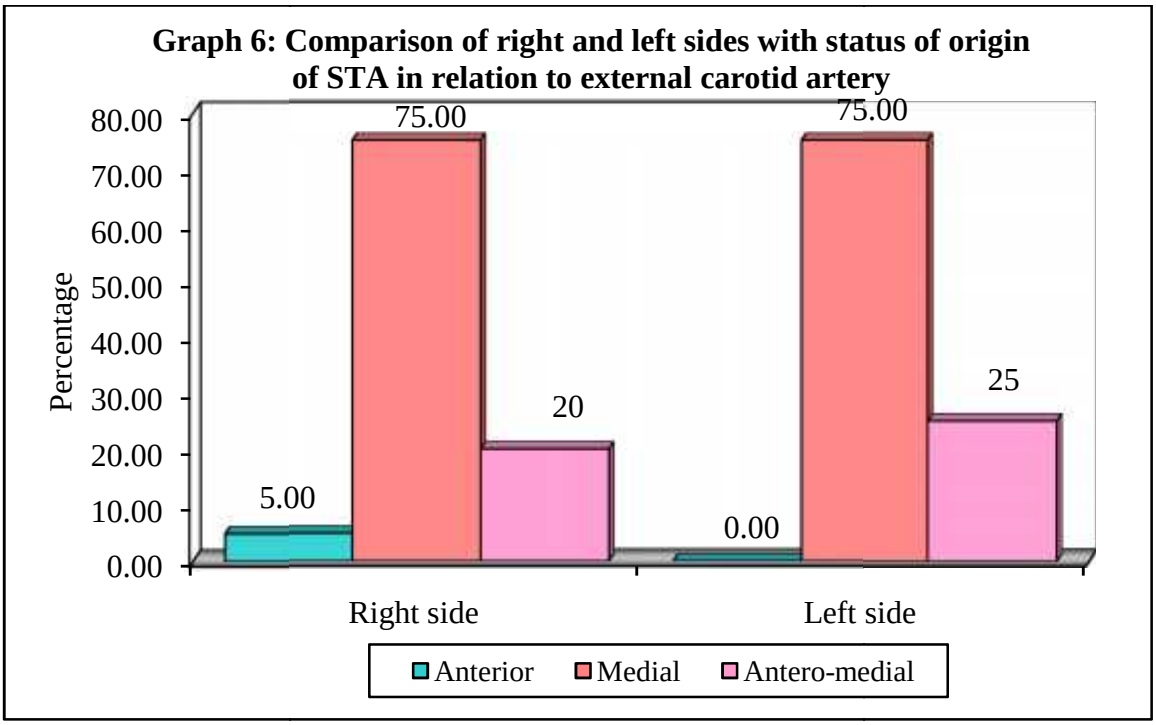
Origin of STA in relation to ECA

Location of the STA from ECA, out of 80 cadaver samples, right and left sides, 60 (75%) cases had a medial location 2 (2.5%) had anterior and 18 (22.5%) had anteromedial location.

Comparison between right and left sides of origin in relation to external carotid artery was not significant with p value of 0.3%. (Table 7, Graph 6)

Table 7: Origin the STA according to the ECA

Origin in relation to external carotid artery	Right side	%	Left side	%	Total	%
Anterior	2	5.00	0	0.00	2	2.50
Medial	30	75.00	30	75.00	60	75.00
Antero-medial	8	20.00	10	25.00	18	22.50
Total	40	100.00	40	100.00	80	100.00
Chi-square= 2.2222 P = 0.3290						



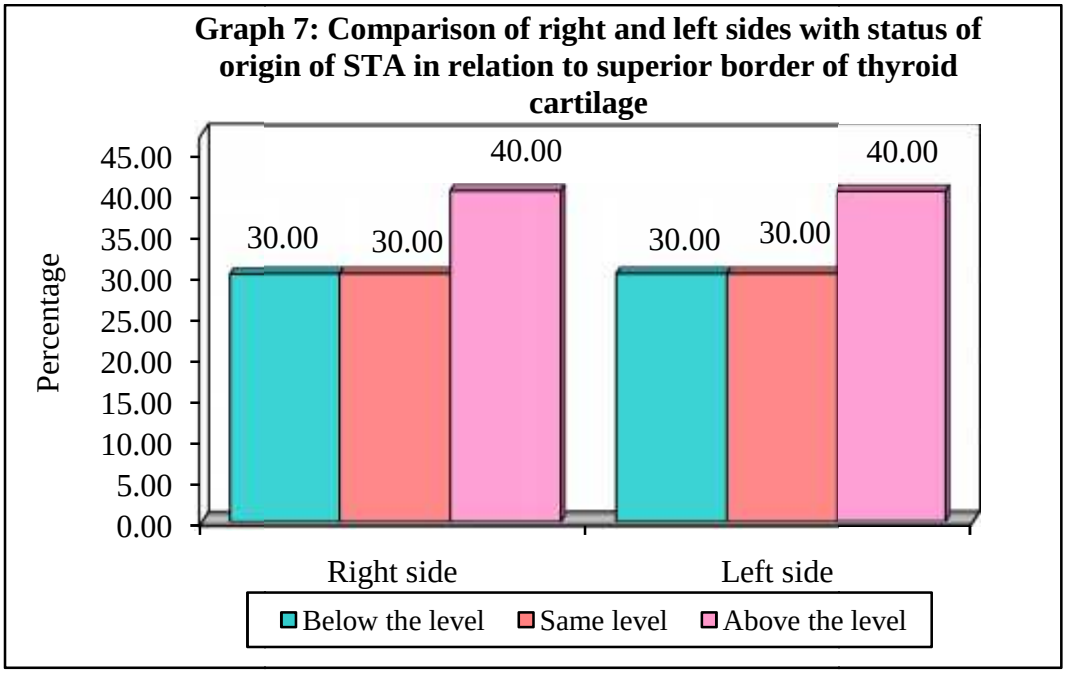
Location of origin STA according to the horizontal plane passing over the top side of the TC"

Out of 80 cadaver samples, right and left sides, 32 (40%) had origin from above the horizontal plane over top of TC, 24(30%) from same level, 24 (30%) origin was below the level of planeover the top side of the TC. (Table 8, Graph 7)

There was no difference in origin on left and right sides (p value- 1.0)

Table 8: Comparison of right and left sides with status of origin of STA in relation to superior border of thyroid cartilage

Origin in relation to superior border of thyroid cartilage	Right side	%	Left side	%	Total	%
Below the level	12	30.00	12	30.00	24	30.00
Same level	12	30.00	12	30.00	24	30.00
Above the level	16	40.00	16	40.00	32	40.00
Total	40	100.00	40	100.00	80	100.00
Chi-square= 0.0000 P = 1.0000						



Branching pattern of superior thyroid artery (STA)

Out of 40 cadaver samples, right and left sides, in 45 sides (56.25%), the infrahyoid branch and superior laryngeal artery (SLA) were divided, followed by the sternocleidomastoid artery and the glandular thyroid branch (Type 1)."

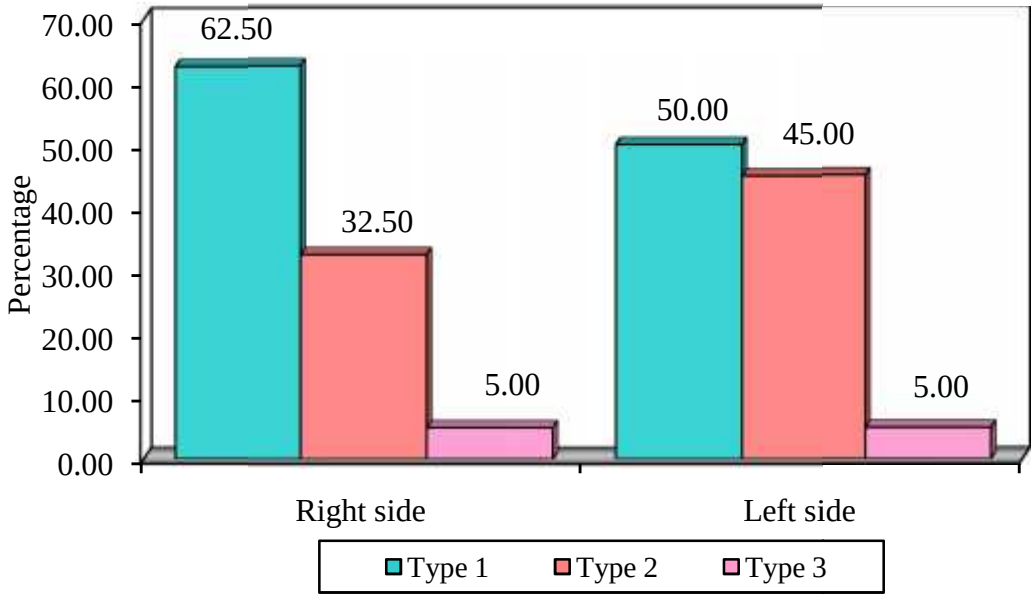
31 sides (38.75%) where infrahyoid branch was divided first and superior laryngeal and sternocleidomastoid branch divided at same level followed by glandular branch (Type 2)."

4 sides (5%) showed type 3 pattern where the infrahyoid branch and sternocleidomastoid artery were divided, followed by the SLA and the glandular thyroid branch (Type 3). (Table 9, Graph 8)"

Table 9: Comparison of right and left sides with status of branching pattern of superior thyroid artery

Branching pattern of superior thyroid artery	Right side	%	Left side	%	Total	%
Type 1	25	62.50	20	50.00	45	56.25
Type 2	13	32.50	18	45.00	31	38.75
Type 3	2	5.00	2	5.00	4	5.00
Total	40	100.00	40	100.00	80	100.00
Chi-square= 1.3622 P = 0.5060						

Graph 8: Comparison of right and left sides with status of branching pattern of superior thyroid artery



Topography of Recurrent Laryngeal Nerve (RLN) in relation to

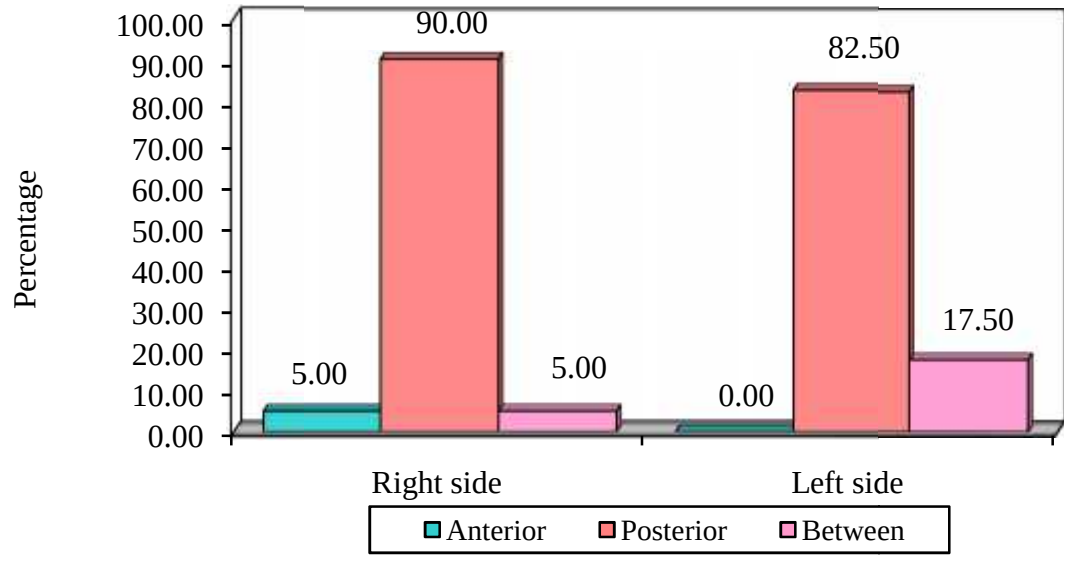
a) Inferior thyroid artery (ITA)

Out of 80 cadaver samples, right and left sides, 69 sides had RLN running posterior to inferior thyroid artery, 9 sides RLN passed in between the branches of inferior thyroid artery and 2 sides RLN passed anterior to ITA. (Table 10, Graph 9)

Table 10: Comparison of right and left sides with status of recurrent laryngeal nerve location in relation to inferior thyroid artery

Location in relation to inferior thyroid artery	Right side	%	Left side	%	Total	%
Anterior	2	5.00	0	0.00	2	2.50
Posterior	36	90.00	33	82.50	69	86.25
Between	2	5.00	7	17.50	9	11.25
Total	40	100.00	40	100.00	80	100.00
Chi-square= 4.9080 P = 0.0860						

Graph 9: Comparison of right and left sides with status of recurrent laryngeal nerve location in relation to inferior thyroid artery

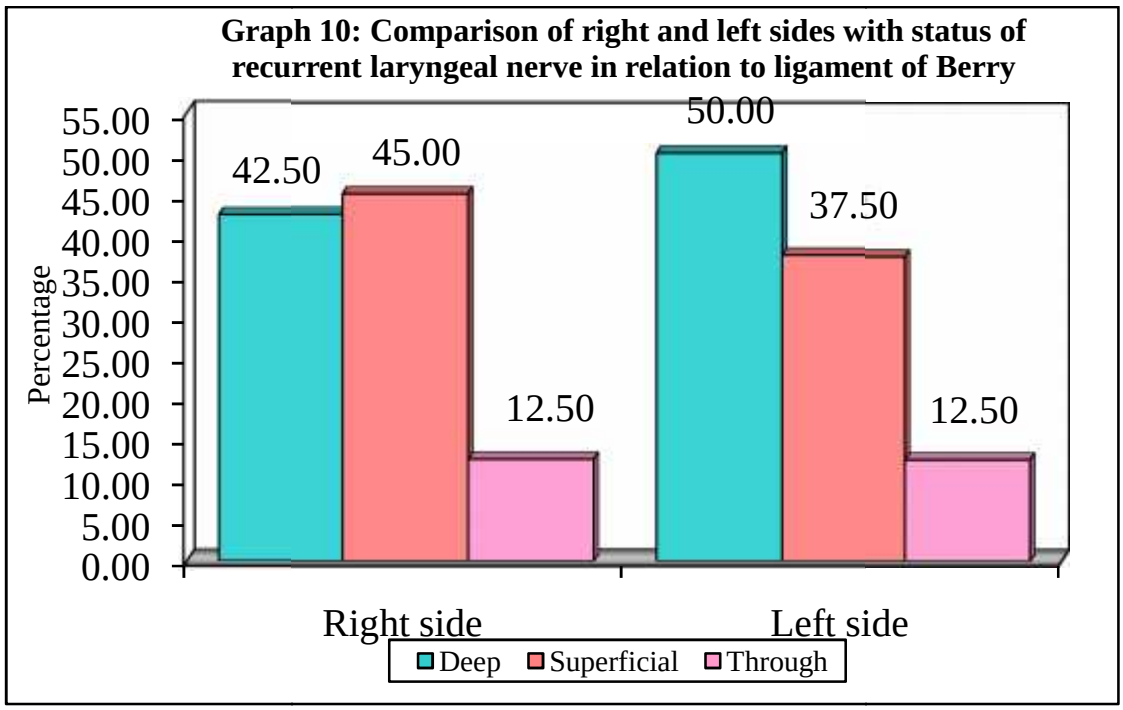


b) With ligament of Berry (LB)

In 46.25% RLN ran deep to LB, 33% superficial to it and 12.50% RLN ran through the LB when left and right sides were considered as a set(Table 11, Graph 10)

Table 11: Comparison of right and left sides with status of recurrent laryngeal nerve in relation to ligament of Berry

In relation to ligament of berry	Right side	%	Left side	%	Total	%
Deep	17	42.50	20	50.00	37	46.25
Superficial	18	45.00	15	37.50	33	41.25
Through	5	12.50	5	12.50	10	12.50
Total	40	100.00	40	100.00	80	100.00
Chi-square= 0.5160 P = 0.7730						

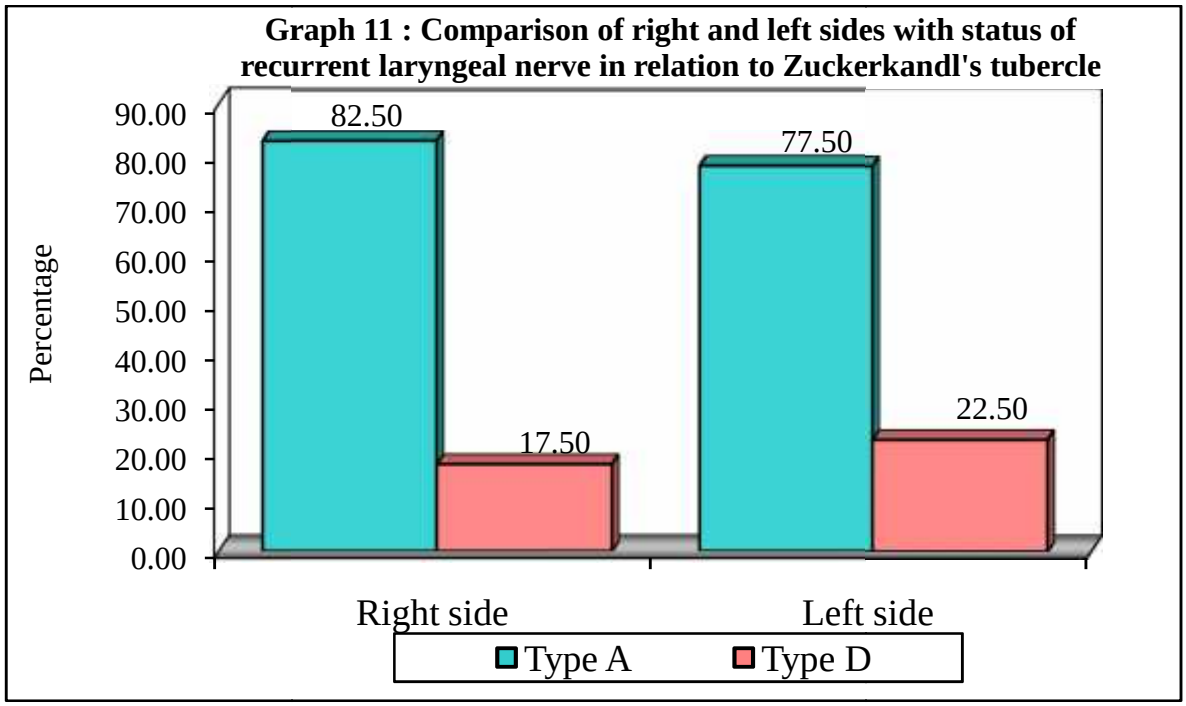


c) To Zuckerkandl's tubercle (ZT)

In 80% considering both sides RLN passed posterior to ZT (type A) and in 20% RLN passed lateral to ZT (type D) (Table 12, Graph 11)

Table 12: Comparison of right and left sides with status of recurrent laryngeal nerve in relation to Zuckerkandl's tubercle

In relation to Zuckerkandl'stubercle	Right side	%	Left side	%	Total	%
Type A	33	82.50	31	77.50	64	80.00
Type D	7	17.50	9	22.50	16	20.00
Total	40	100.00	40	100.00	80	100.00
Chi-square= 0.3131 P = 0.5760						

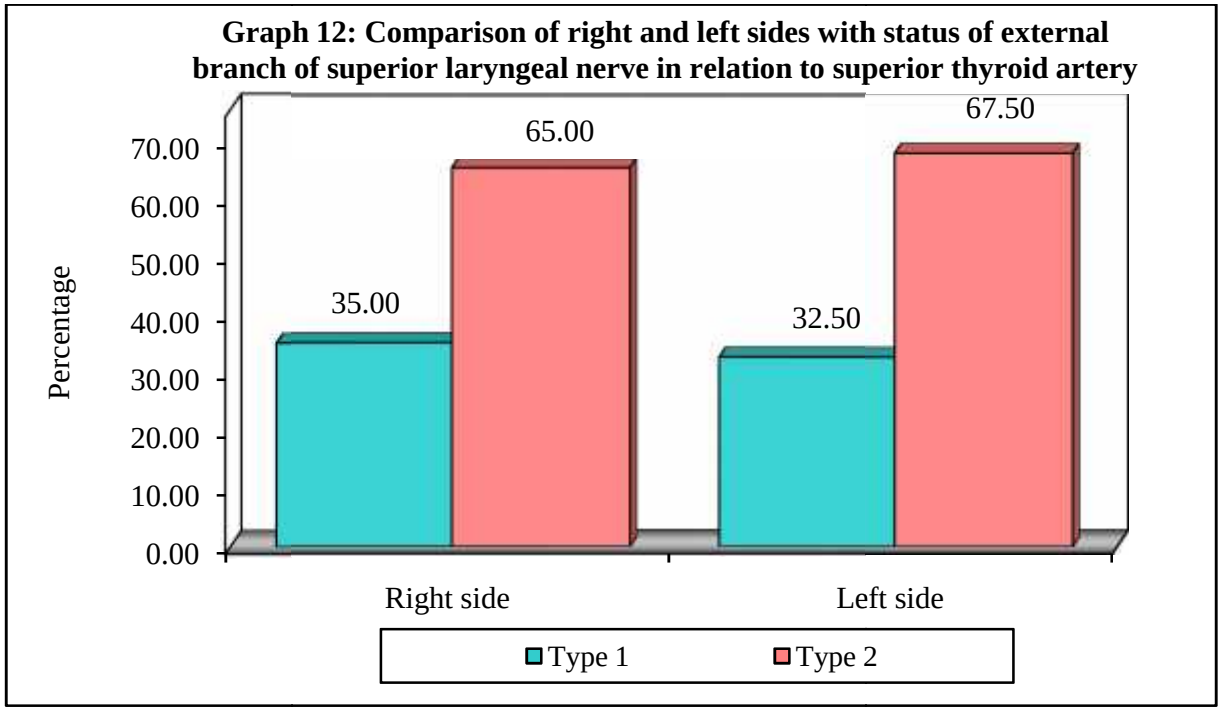


External branch of Superior Laryngeal Nerve (EBSLN) and its relation to STA"

Distance between STA and the external branch of SLN was found to be >1cm (type 1) in 27 sides (33.75) and <1cm (type 2) in 53 sides (66.25%) (Table 13, Graph 12)

Table 13: Comparison of right and left sides with status of EBSLN in relation to STA

In relation to Superior thyroid artery	Right side	%	Left side	%	Total	%
Type 1	14	35.00	13	32.50	27	33.75
Type 2	26	65.00	27	67.50	53	66.25
Total	40	100.00	40	100.00	80	100.00
Chi-square= 0.0560 P = 0.8130						

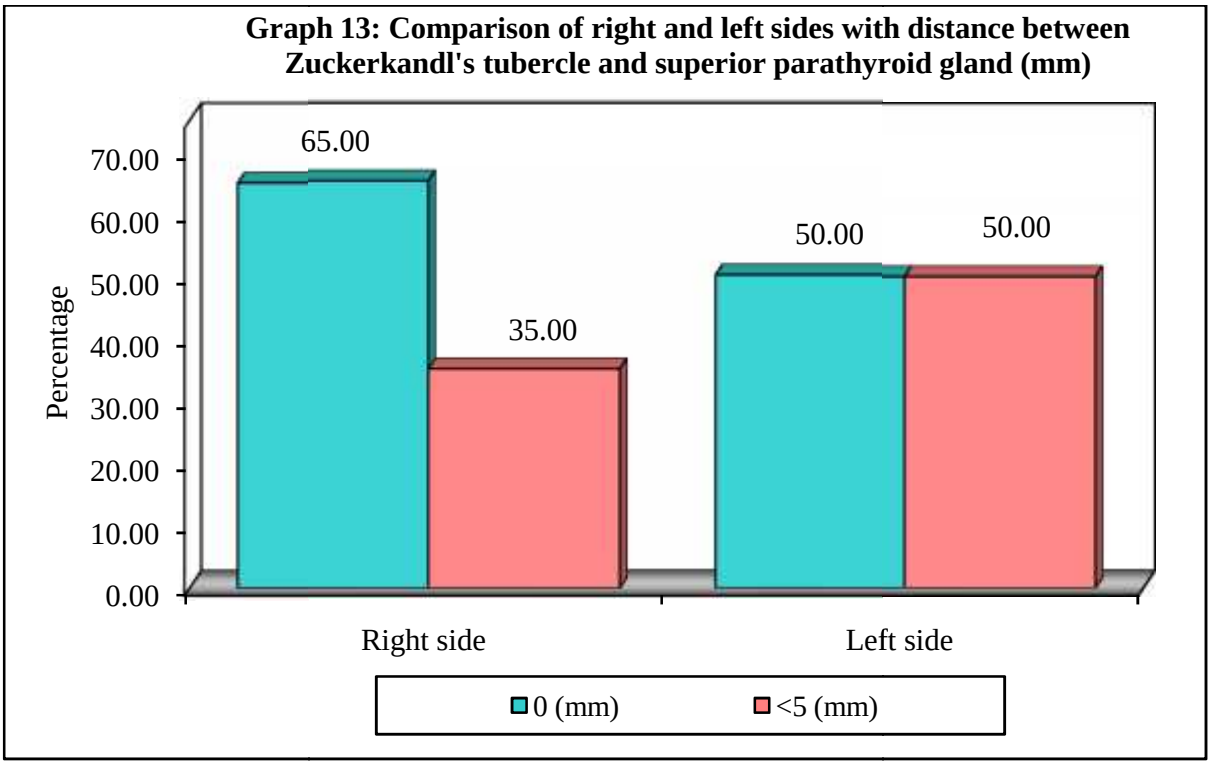


Zuckerkandl's tubercle (ZT) and superior parathyroid (SP)

Out of 40 cadavers, left and right sides, the distance between Zuckerkandl's tubercle and superior parathyroid was observed to be less than 5mm in 34 (42.50%) and 0mm in 46(57.50%) specimens. (Table 14,Graph 13)

Table14: Comparison of right and left sides with distance between Zuckerkandl'stubercle and superior parathyroid gland (mm)

Distance	Right side	%	Left side	%	Total	%
0 (mm)	26	65.00	20	50.00	46	57.50
<5 (mm)	14	35.00	20	50.00	34	42.50
Total	40	100.00	40	100.00	80	100.00
Chi-square= 1.8410 P = 0.1750						



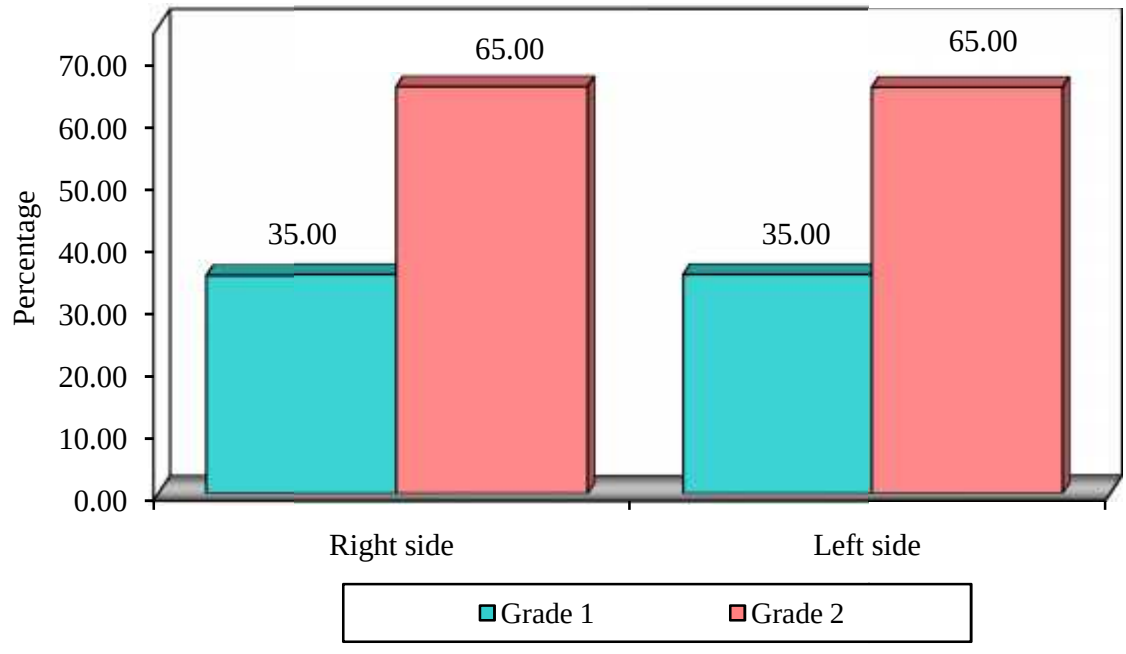
Incidence of Zuckerkandl's tubercle

In 28 sides ZT was observed as grade 1(<5mm) and in 52 sides as grade 2 (6-10mm). (table 15, graph 14)

Table 15: Comparison of right and left sides with status of Zuckerkandl's tubercle

Zuckerkandl'stubercle	Right side	%	Left side	%	Total	%
Grade 1	14	35.00	14	35.00	28	35.00
Grade 2	26	65.00	26	65.00	52	65.00
Total	40	100.00	40	100.00	80	100.00
Chi-square=0.0000 P = 1.0000						

Graph 14: Comparison of right and left sides with status of Zuckerkandl's tubercle



DISCUSSION

Thyroid gland is located on the anterolateral part of cervical trachea. During development, it descends down from floor of pharynx to reach its final position in neck. Some remnant tissues persist along the course and give rise to different THY-GL anomalies of shape such as additional lobes, pyramidal lobe, lingual thyroid, median cysts or fistulae and additional thyroid structures.[23]Thorough knowledge of the types and accessory lobes allows modification of surgical technique to minimise bleeding during thyroidectomy.

The thyroid gland is a vascular organ. The main arterial supply of THY-GL is STA. The variation in paths of the branches of STA, and their association with surrounding structures plays an important role for diagnosis & treatment of parathyroid and thyroid glands .[3]

STA is first branch of the ECA. It has a varied origin and seen as taking origin at the same level of CB or from the CCA. STA usually arises from anteriorsurface of the ECA below the level of the greater cornuof the hyoid.[77] The STA courses along the EBSLN, running antero-inferiorly toward thyroid apex.[76,77]

Five branches of the STA have been observed: the infrahyoid, sternocleidomastoid, SLA, cricothyroid, and terminal glandular branches to supply the gland. [78-83]

The main blood vessel which is considerably distributed in the larynx is **Superior laryngeal artery**. It has variable origin, in 80% of cases it had origin from the STA and sometimes can arise directly from ECA.

Infrahyoid branch supplies sternothyroid, sternohyoid and superior belly of omohyoid muscles.

Cricothyroidartery generally originate from STA, anastomoses with SLA deep to TC. It crosses anterior cricothyroid ligament and anastomose with its bramch of the other side.

The anterior glandular branches (AGB) runs along the medial side of the lateral lobe and supplies anterior surface via anteromedial and anterolateral glandular branches.

The posterior glandular branch (PGB), descends on posterior border to supply the medial and lateral surfaces.

Sternocleidomastoid branch descends laterally across the carotid sheath and supplied the middle region of sternocleidomastoid.

Thyroid gland is closely related to important structures in neck. These are cervical esophagus, recurrent laryngeal nerve (RLN), major vessels, superior laryngeal nerve (SLN), and parathyroid glands. Knowledge about precise anatomy of related structures plays a vital role in thyroidectomies. The RLN shows a great number of topographical relations to the adjacent cervical structures because of the multiple variations in its course is an important but avoidable complication of thyroidectomy. The complication resulting from injury to the recurrent laryngeal nerve (RLN) can be evaded by the identifying landmarks of the nerve.

The external branch of SLN reaches upper pole of thyroid gland by crossing behind the external and internal carotid arteries along with STA. Upper pole of thyroid gland is the most susceptible site for injury during thyroid surgery, therefore, knowledge about the course of SLA is necessary to avoid post-operative complications.

Parathyroid glands regulates calcium levels, occurs in numeral variations in location and extra number of glands. This makes it difficult to avoid their injury during surgical exploration, therefore it is important to know these variations for better surgical outcome.

Typically, paired superior and inferior glands develop for a total of four, although up to 13% incidence of supernumerary glands has been described, up to 11 glands in large autopsy series.[59]Most cases have four parathyroid glands, five or more have been found. These supranumeric structures are commonly located in "thymus" region.[68]Detailed anatomical knowledge of these glands is fundamental to avoid postsurgical hypoparathyroidism, such as failures during thyroidectomy and parathyroid procedures.

The present study involved neck dissection in 40 cadavers, out of which 27(67.50%) were males and 13 (32.50%) were females. Ozgur et al [3] had 17 (85%) males and 3 (15%) females in his study, Monfared et al [25] had 12 (57.14%) males and 9 (42.8%) females, Kierner et al [46] studied 31 cadavers in which 20 (64.5) were males and 9 (29%) were females.

In present study age distribution varied from 39-106 years with mean age of 73.98 years. Ozgur et al [3] in his study had a mean age of 55 years with age distribution

ranged from 40-70 years. Monfared et al [25] studied cadavers with age ranging from 53-92 years.

Anatomical aspects of lobes of thyroid gland was studied andthe present study showed presence of PYR-L in 52% of cases and in remaining 47.5% a horseshoe shaped gland without a PYR-L was observed, which was similar to study done by Ozgur et al(2011)[3] and Skandalakis et al(2004).[85]

The PYR-L extends superiorly from isthmus of thyroid gland, most commonly to the left of the median plane, which was consistent with the present study. In 14 specimens (35%) PYR-L originated from left part of isthmus, in 2 specimens (5%) PYR-L originated from midline and 5 (12.50%) specimens had PYR-L attached to oshyoideum with LGT.

Braun et al(2007)[18]observed PYR-L in 43% (40–80%) of specimens from which 65.4% extended to the hyoid bone, and rest 34.6% reached thyroid cartilage upper part.The present study showed the PYR-L in 52% of specimens out of which 22.7%, extended to hyoid bone and 77.3% reached thyroid cartilage upper part.

Distance from origin of STA with surrounding relations as observed **i**n our study of 40 cadaver samples, right and left sides, the distanceof STA to the CB was3.08 ± 1.88 mm, with minimum distance of 0.2mm and maximum of 6.40mm,which was similar to study conducted by Ozgur et al(2009)[3] where it was 3.29 ± 4.27 mm.

The distance from the origin of the STAto that of the LA in present study ranged from 7.80 ± 2.11 mm, the distancefrom the origin of the STA to that of the FA

was14.73 ± 3.00 mm. Ozgur et al (2009)[3] observed the distance from STA to LA was 10.45 ± 5.16 mm, and the distance from the STA to FA was 18.20 ± 8.81 mm.

The distance to superior laryngeal nerve in present study was 5.9 ± 4.9 as compared to 8.42 ± 1.33 mm observed by Ozgur et al (2009).[3]

In present study, the distance to hypoglossal nerve was observed as 18.35 ± 2.27 mm and to the thyroid cartilage upper edge was 4.52 ± 1.94 when compared with the study by Ozgur et al (2009)[3] the distance to hypoglossal nerve was 12.8 ± 7.2 and to thyroid cartilage upper edge was 7.1 ± 6.4. No significant differences were observed in right and left side comparison of the data .

In present study, out of 40 cadavers, when right & left sides is considered as a set, in 16(20%) sides STA arose from below the level of carotid bifurcation that is STA arose from common carotid artery (CCA), 32(40%) arose from same level of carotid bifurcation and 32 (40%) from above the level of carotid bifurcation that is from ECA. There was no significant difference between left & right sides with P value >0.01.

Our study was similar to study conducted by Ozgur et al(2009)[3]where STA arose at same level with CB in most of cases (40%), in 35% it arose below the level of CB and in 10% above the level of CB.

Other studies by Shima et al (1998)[76] and Hayashi et al (2005)[78]found STA originated from ECAin 30–70% of the cases. Inliterature, the STA originate from theCCA, thyrolinguofacial trunk, ECA have been observed.[27]

Assessing the location of the STA from ECA, in present study out of 80 cadaver samples, right and left sides, 60 (75%) sides had a medial location, 2 (2.5%) had anterior and 18 (22.5%) had anteromedial location.

Ozgur et al (2009)[3]in their study observed STA arose mostly (82.5%) from medial wall of ECA, in 10% STA had anterior location and 5% had anteromedial location.

Comparison between right & left sides of origin in relation to external carotid artery was not significant with p >0.05% in present study.

In our study, out of 80 cadaver, right & left sides, 32 (40%) STA had origin from above the parallel plane crossing over top of the thyroid cartilage, 24(30%) from same level, 24 (30%) origin was below the level of planecrossing over top level of TC.

Ozgur et al(2009)[3] in their study STA was found to be above in 60%, below in 22.5%, and at the same level in 17.5% cases which was similar to our observations.

Branches of STA had a variable origin and course. In present study, **SLA** originated from STA in 100% cases. Ozgur et al (2009)[3] in their study observed in 85% (34) of specimens, the SLA arose from the STA and in rest of 15% (6) it originated from ECA.

In present study in all specimens, **infrahyoid artery** passed parallel to hyoid bone deep to thyrohyoid membrane. It originated from STA in 100% cases. In the study by Ozgur et al (2009)[3] 85% (34) of specimens, the infrahyoid branch had its origin from STA and 15% (6) had origin from ECA. In the study by Gormus et al (2004)[83] reported that the infrahyoid branchhad origin from the STA (70–100%).

In present study **cricothyroid branch** originated from anterior glandular branch in 100% cases as compared to observation by Ozgur et al (2009)[3] where the cricothyroid branch originated from anterior glandular branch in 70% (28) of specimens, in 30% (12) it had origin from STA.

In our study**, anterior glandular branch (AGB)** ran on medial surface of lobe and anastomosed with its fellow of the other side; and a **posterior glandular branch (PGB)**, ran on the posterior border to supply the medial and lateral surfaces. Ozgur et al (2009)[3] reported AGB separated from STA and PGB separated from STA before reaching the upper pole of lobes of thyroid gland in 85% and dispersed on glands posterior surface.

In the present study, the **sternocleidomastoid branch** arose as 1st branch in 5%, 2nd branch 56.25% and in 38.75% the three branches divided at one point. Issing PR et al (1994)[84] reported the sternocleidomastoid branch originated as 1st branch in 20%, 2nd branch 36% and in 16% the three branches divided at one point.

In present study in 100% cases the sternocleidomastoid artery originated from the STA as compared to study by Ozgur et al (2009)[3] where in 80% (32) of specimens, the sternocleidomastoid artery arose from STA and in 20%(8), it originated from ECA.

In our study out of 40 cadaver samples, right and left sides, in 45 sides (56.25%), theinfrahyoid branch and SLA were divided, followed by thesternocleidomastoid artery and the glandular thyroidbranch (Type 1).Ozgur et al (2009)[3] observed Type 1 in 31 sides (38.75%).

In seven cases (17.5%), the infrahyoid branch was divided and then the three branches (superior laryngeal, thyroid glandular and sternocleidomastoid branches) were divided at one point (Type 2). Ozgur et al (2009)[3] observed Type 2 in six cases (15%).

4 sides(5%) showed type 3 pattern where theinfrahyoid branch and sternocleidomastoid artery were divided, followed by the SLA and the glandular thyroidbranch (Type 3). Ozgur et al(2009)[3] Type 3 in seven cases (17.5%).

Hu et al(2006)[87] observed that in Type I, 36%, the superior SLA is divided first, followed by sternocleidomastoid branch and thyroid branch. In Type II, 16%, the three branches are divided at one point. 10% of the cases are observed as Type III, where the sternocleidomastid is divided first from the STA, followed by the superior laryngeal branch and the glandular thyroid branch.

No differences were observed in the right-left side comparison of the data about all the parameters.

The dreaded complication during thyroid surgeries is damage to the STA and branches. This is evaded by having an insight about these variations.

We observed **RLN** had a variable relation with **ITA**. On right, the nerve passed posterior artery in 36 cadavers, in 2 cadavers the nerve passed anterior to artery and in 2 cadavers passed in between the branches of artery. Similarly on left, the nerve passed posterior artery in 33 cadavers; however the nerve passed between the branches of artery in 7 cadavers and had no anterior relation to artery. In a study led by Monfared et al (2002)[25] the nerve passed anterior (21%) or posterior (28%) to its

branches, on right. The nerve passed posterior to the branches of the artery (50%), between its branches (28%), and anterior to RLN (21%) on the left side.

In the analysis of present study, higher frequency (86.25%) of posterior location of RLN to the ITA when both sides were considered as a set, followed by in between the branches of artery (11.25%) and least frequency of anterior location (2.50%) which was similar to study conducted by Kaisha et al (2011)[75]

The relationship of the **RLN to LB** has been debated in the literature. In present study we observed in majority of cadavers (46.25%) the nerve ran deep to ligament of berry, when both the sides were considered as a set followed by superficial to ligament in (41.25%) and (12.5%) through the ligament.

Sasou et al (1998)[12] in their study found RLN was dorsolateral to ligament of Berry in all the cases.

The RLN is usually found to be medial, lateral or be embedded in Berry's ligament. [28]

Our study was similar to study conducted Kaisha et al (2011)[75] where the RLN passed superficial to the ligament in 66.9% and it passed through the ligament in 7.4% of cases.

The ZT was found to be a reliable landmark to the nerve in our study. Pelizzo et al (1998)[42] classified the relation in course of RLN with ZT as Type A- posterior to ZT surface, Type B – anterior to ZT, Type C and Type D- passing through ZT and lateral to ZT respectively.

The present study found that **location of RLN in relation to ZT** in 64 sides (80%) was posterior (type A) and in 16 sides (20%) nerve lied lateral to it (type D). Our observation was similar to study by Yun et al (2008)[43] where type A was found in 92.1%.

Kierner et al (1998)[46] classified the topographical relationship of EBSLN to the STA into 4 categories. The present study showed distance between STA and the EBSLN was >1cm (Type 1) in 27 sides (33.75) and <1cm (Type 2) in 53 sides (66.25%).

In the study by Kierner et al (1998)[46] showed Type 1 to be the most common type observed in 21 specimens (42%), type 2 in (30%), type 3 and type 4 in 14% specimens each.

In all 40 cadaveric dissections, number of parathyroid per case was found to be 4, no superanumericparathyroid were found. No ectopic parathyroid glands were found.

In study conducted by Hojaji et al(2011)[71] four number of parathyroid were found in 44 out of total 56 cases (78.6%), supranumeric gland were seen in 7 cases(10.7%) of which majority were located in the mediastinum.

The ZT is significant anatomical landmark for preservation of the superior parathyroid during surgeries. The SP is usually located in the upper portion behind the RLN and ITA. The most common location observed are between 1-2 o'clock and 10-11 o'clock positions.

Out of 40 cadavers, left and right sides, the distance between ZT and superior parathyroid was observed to be less than 5mm in 34 sides (42.50%) and 0mm in 46 sides (57.50%) specimens.

This observation was similar to the study conducted by Hojaji et al(2011)[71] where 95.6% of cases the SP was located in cranial portion of ZT(Grade 2) that is either adhered(0mm) or within 5mm away and for ZT (Grade 1) the location of SP was >5mm away in 7 cases(4.4%)

The ZT is an important anatomical landmark during thyroid surgeries due to its relationship with the RLN and the SP. [42,43]

Pelizzo et al (1998)[42] in his study divided ZT into 4 grades as- Grade 0- unrecognizable, Grade 1- <5mm, Grade 2- 6-10mm, Grade 3- >10mm

In the present study most of the specimens (52 sides, 65%) size of ZT was found to be grade 2 (6-10mm). In 28 sides (35%) size of ZT was observed as grade 1(<5mm). This observation was consistent with the study conducted by Yun et al (2008)[43] where 87.5% of ZT were higher than grade 1 that is >6mm.

CONCLUSION

Surgical procedures in the zone of the vital structures in neck like thyroid gland, larynx should be performed carefully by surgeons and they should be aware of the possible dimensions and variations that can be present in the region to avoid complications.

Forty cadavers of variable age and gender were studied about thyroid gland and its extensions, the pyramidal lobe and levatorglandulaethyroidae, The present study showed presence of pyramidal lobe in 52%

The variation in courses of the branches of superior thyroid artery, its association with the surrounding structures were assessed and correlated.

Topography of recurrent laryngeal nerve was studied in relation to inferior thyroid artery, ligament of Berry and ZT. RLN is mainly a posterior relation of the inferior thyroid artery (86.25%). The tubercle of Zuckerkandl, when present, is a valuable landmark while locating the RLN and showed in 46.25% RLN ran deep to it. The ligament of Berry also make a reliable landmark to the identification of the RLN.

The EBSLN has a variable relation with superior thyroid artery which was observed to lie at a distance of <1cm from STA in 66.25%.

Knowledge about location and number of parathyroid glands is necessary to avoid their damage and post surgical complications. In our study Zuckerkandl's tubercle formed a useful and constant landmark for superior parathyroid.

This study assess the possible morphology and anthropometric variation of the thyroid gland and its surrounding relation that can exist in indian cadavers.

SUMMARY

This study involved neck dissection in total 40 fresh frozen cadavers with objective to study morphometric details, anatomical distribution and variations of thyroid gland and its surrounding relations for surgical implications.

In our study, the types of lobes thyroid gland its morphometric specifications, the pyramidal lobe and the levatorglandulaethyroidea were assessed. A thorough knowledge of arterial supply of thyroid gland allows modification of surgical techniques and minimise the risk of bleeding while doing thyroid surgeries.

With discrete arterial blood supply by superior thyroid artery, injury to it causes a lethal acute haemorrhage. We studied the variations in the origin of the artery, its distance from surrounding structures and its branching patterns.

We observed the variable relationship between recurrent laryngeal nerve and the inferior thyroid artery, the tubercle of Zuckerkandl, and the ligament of Berry. RLN is mostly a posterior relation of ITA. The ZT is valuable landmark for locating the RLN when present, LB and ZT when combined, make dependable landmarks for the localizing the recurrent laryngeal nerve.

The external branch of superior laryngeal nerve supplies parts of mucous membrane of larynx, also gives motor fibers to intrinsic muscles of larynx, palsy of which may cause dysphonia and aspiration. A better understanding of the structural anatomy of superior laryngeal nerve and its branches aids in identifying and safeguarding the nerve during neck surgery.

Careless removal of parathyroid gland is the major consequence in thyroid surgery due to which a decrease in serum calcium levels is observed postoperatively and this causes grave impairment and even death due to spasm of laryngeal/respiratory muscle. So the knowledge about anatomy of parathyroid gland is extremely necessary for any surgeon.

The anatomic variations may be minor in degree but are important as they may affect the outcome of surgery and the quality of life of patients. Therefore, having a thorough awareness of typical anatomy safeguards the integrity and protection of the important structures.

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ANNEXURE I

ETHICAL CLEARANCE CERTIFICATE

K.L.E. ACADEMY OF HIGHER EDUCATION AND RESEARCH
(Deemed – to- be- University)
Accredited 'A' Grade by NAAC (2nd Cycle) Placed in Category 'A' by MHRD (GoI)
JAWAHARLAL NEHRU MEDICAL COLLEGE,
NEHRU NAGAR, BELAGAVI-590010 (KARNATAKA-INDIA)
Website: http//www.jnmc.edu
E-Mail : dome@jnmc.edu
Phone: (+ 91-(0)831 Office : 2472550
Principal: 2471701
Fax No. +91 (0)831 – 2470759

Ref: MDC/DOME/62 **Date: 24/11/2018**

To,

Dr.
PG student in Otorhinolaryngology,
J.N.Medical College,
BELAGAVI.

Sub: Institutional Ethical Clearance for the study.

With reference to the above, we wish to inform you that your proposed research project titled **"MORPHOMETRIC EVALUATION OF VARIOUS TOPOGRAPHY OF THYROID GLAND FOR SURGICAL CRUCIALITY: AN OBSERVATIONAL CADAVERIC STUDY",** is ethical and justifiable. The proposed research project has been cleared by the JNMC Institutional Ethics Committee on Human Subjects Research.

(Dr. Arathi Darshan)
Member Secretary
JNMC Institutional Ethics Committee
on Human Subjects Research,
J.N.Medical College, Belagavi.

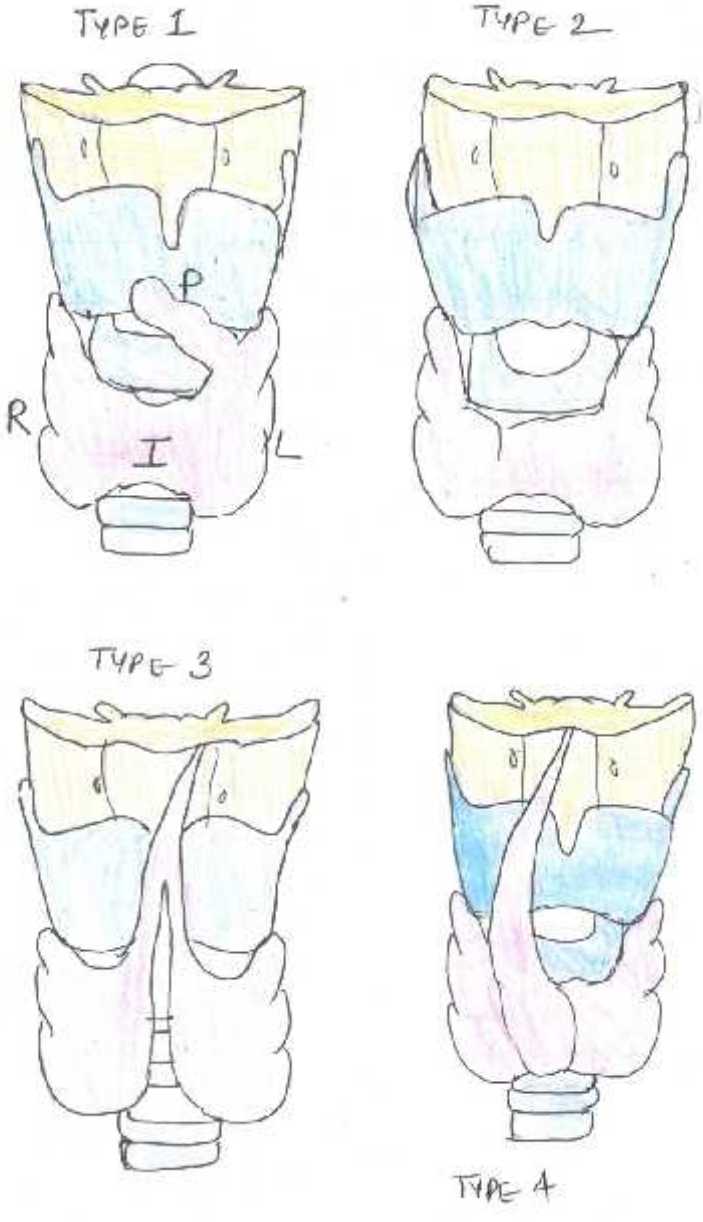
(Dr. Roopa M Bellad)
Chairman,
JNMC Institutional Ethics Committee
on Human Subjects Research,
J.N.Medical College, Belagavi.

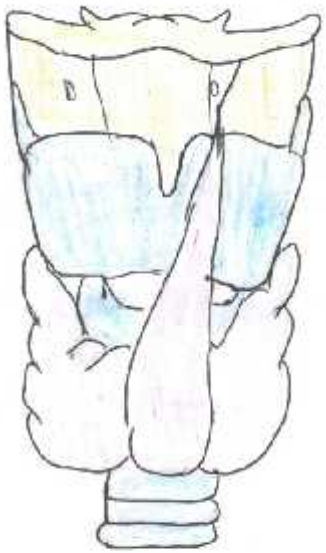
ANNEXURE III

PROFORMA FOR DATA COLLECTION

S.No:
NAME : **AGE:** **SEX:**

ANATOMICAL AND SURGICAL ASPECTS OF LOBES OF THYROID GLANDS-





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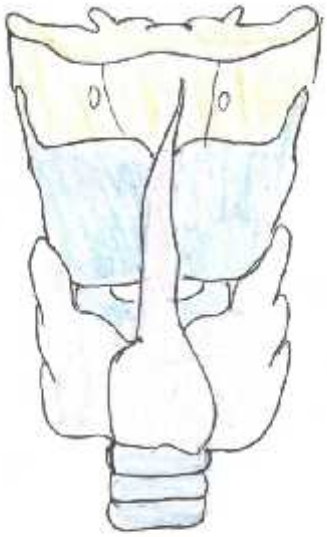

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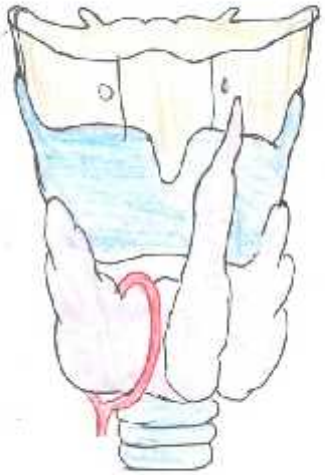

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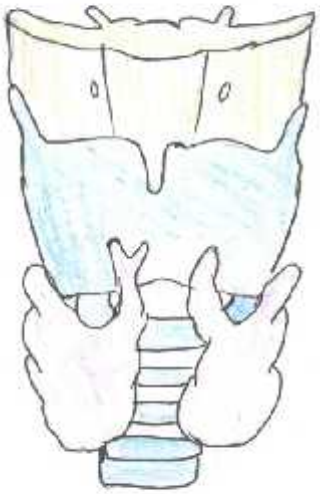


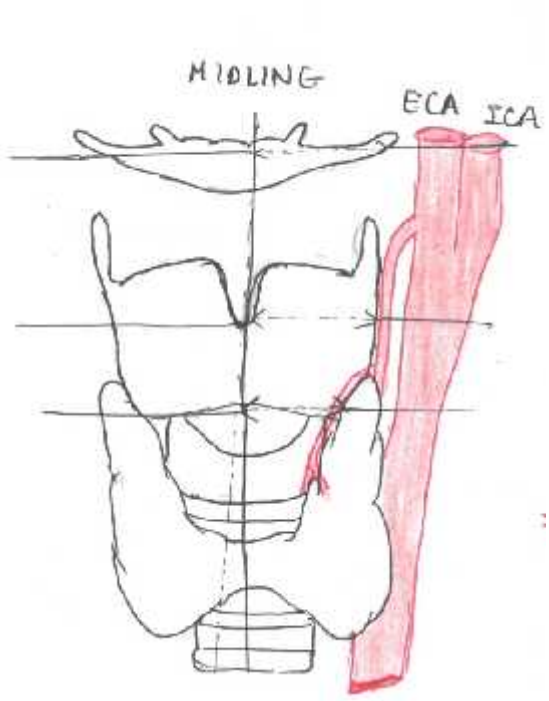
TYPE 9

TYPE 10

TYPE 11

TYPE- 12

2) SUPERIOR THYROID ARTERY (STA)



a) ORIGIN OF STA-

-DISTANCE OF ORIGIN OF STA TO RIGHT LEFT

CAROTID BIFURCATION

LINGUAL ARTERY

FACIAL ARTERY

SUPERIOR LARYNGEAL NERVE

HYPOGLOSSAL NERVE

THYROID CARTILAGE

- LOCATION OF POSITION OF ORIGIN OF STA ACCORDING TO CAROTID BIFURCATION RIGHT LEFT

ABOVE THE LEVEL OF CB

SAME LEVEL WITH CB

BELOW THE LEVEL OF CB

- LOCATION OF POSITION OF ORIGIN OF STA ACCORDING TO EXTERNAL CAROTID ARTERY (ECA)

ECA LOCATION	RIGHT	LEFT
MEDIAL		
ANTERIOR		
ANTEROMEDIAL		
INFEROMEDIAL		

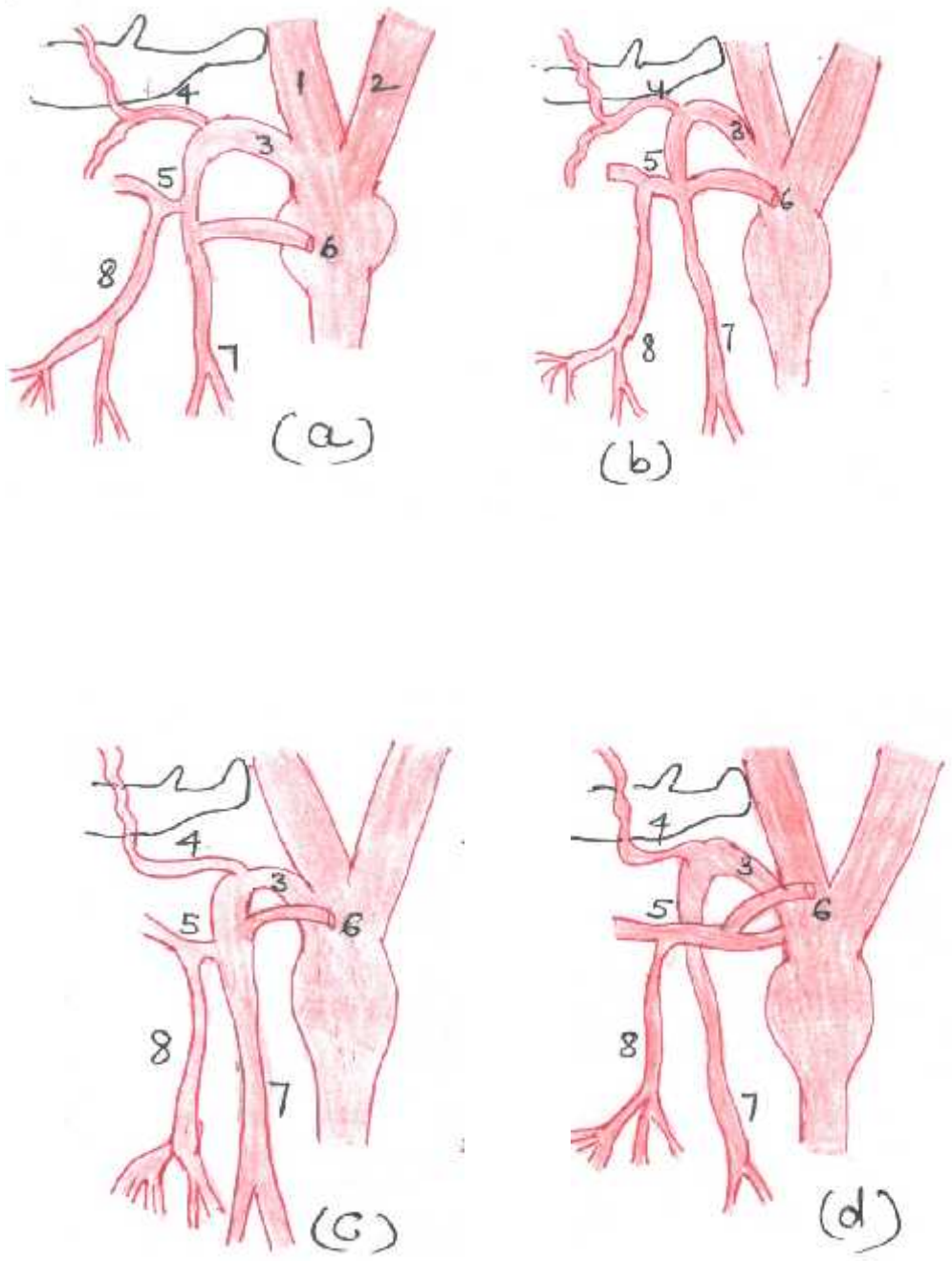
- ORIGIN OF STA ACCORDING TO HORIZONTAL PLANE PASSING OVER TOP SIDE OF THYROID CARTILAGE (TC)

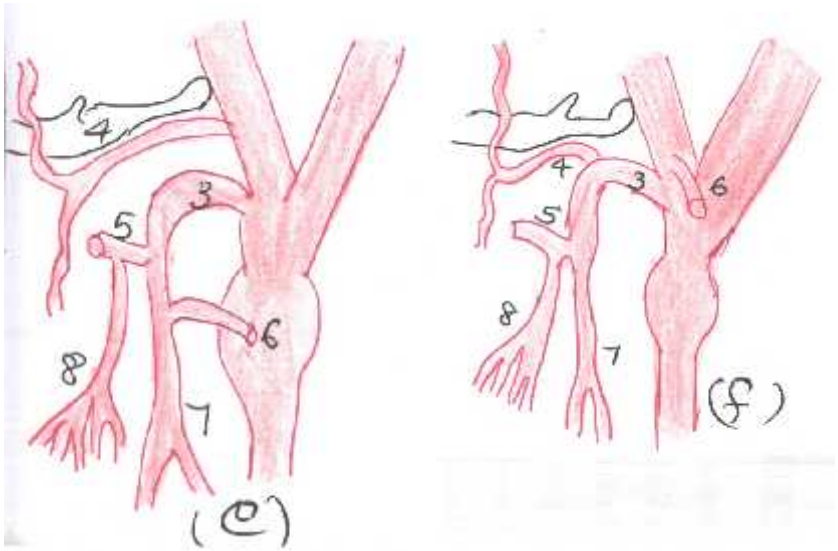
LOCATION	RIGHT	LEFT
ABOVE TC		
SAME LEVEL WITH TC		
BELOW TC		

- BRANCHING PATTERN OF STA-

	RIGHT	LEFT
TYPE 1		
TYPE 2		
TYPE 3		
TYPE 4		
TYPE 5		
TYPE 6		

The branching types of the superior thyroid artery. 1 external carotid artery, 2 internal carotid artery, 3 superior thyroid artery, 4 infrahyoid branch, 5 superior laryngeal artery, 6 sternocleidomastoid branch, 7 anterior glandular branch, 8 cricothyoid branch





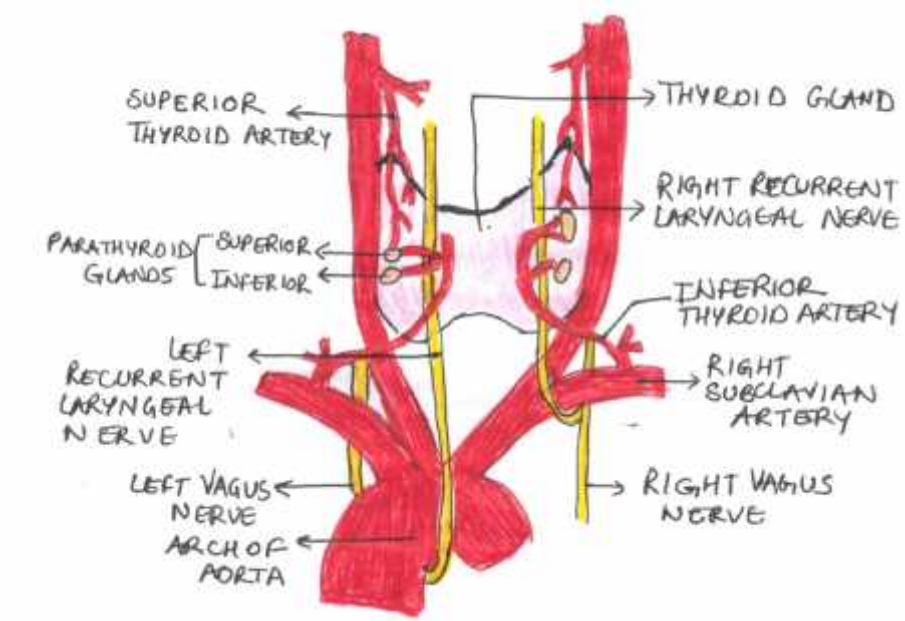
The branching types of the superior thyroid artery. 1 external carotid artery, 2 internal carotid artery, 3 superior thyroid artery, 4 infrahyoid branch, 5 superior laryngeal artery, 6 sternocleidomastoid branch, 7 anterior glandular branch, 8 cricothyoid branch

3) TOPOGRAPHY OF RECURRENT LARYNGEAL NERVE IN RELATION TO

a) INFERIOR THYROID ARTERY

b) WITH LIGAMENT OF BERRY (LB)

c) TO ZUKERKANDL'S TUBERCLE



a) INFERIOR THYROID ARTERY

LOCATION	RIGHT	LEFT
ANTERIOR		
POSTERIOR		
BETWEEN		

b) WITH LIGAMENT OF BERRY (LB)

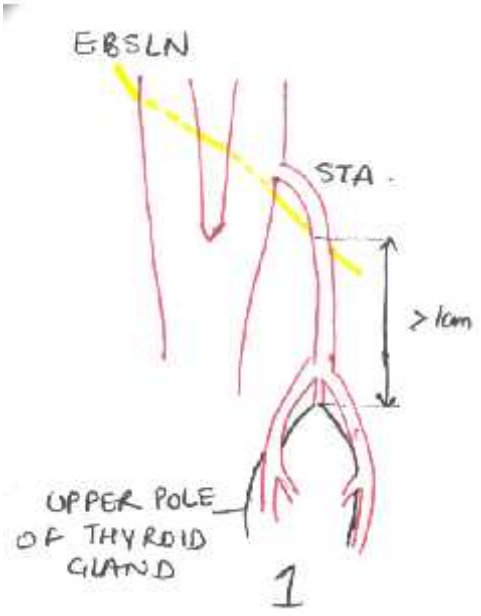
LOCATION	RIGHT	LEFT
SUPERFICIAL		
DEEP		
THROUGH LIGAMENT		

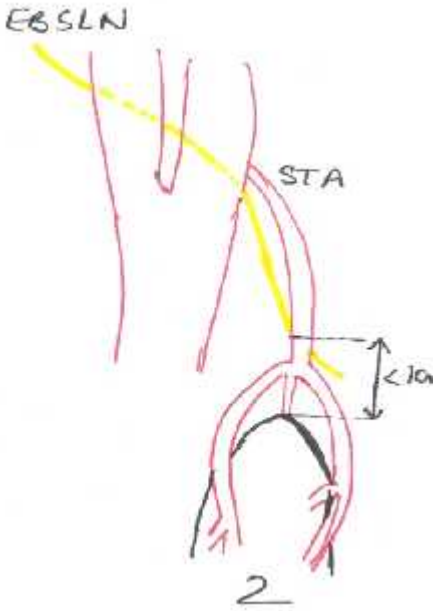
c) TO ZUKERKANDL'S TUBERCLE

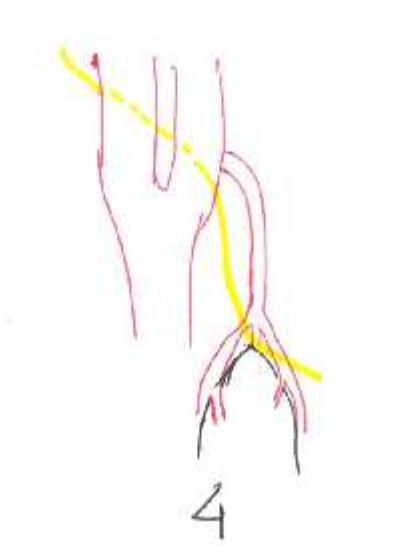
	RIGHT	LEFT
TYPE A		
TYPE B		
TYPE C		
TYPE D		

4) EXTERNAL BRANCH OF SUPERIOR LARYNGEAL NERVE AND ITS

RELATION TO STA







RIGHT LEFT

TYPE 1

TYPE 2

TYPE 3

TYPE 4

5) PARATHYROID ANATOMICAL DISTRIBUTION

a) PARATHYROID NO-

b) SUPRANUMERIC PARATHYROID LOCATION-

6) ZUKERKANDL TUBERCLE AND SUPERIOR PARATHYROID

RIGHT LEFT

a) DISTANCE BETWEEN ZT AND SP-

7) INCIDENCE OF ZUKERKANDLE TUBERCLE-

GRADE 0

GRADE 1

GRADE 2

GRADE 3

ANNEXURE - III

PHOTOGRAPHS

1. Common carotid artery
2. Carotid bifurcation
3. External carotid artery
4. Internal carotid artery
5. Superior thyroid artery
6. Thyroid gland
7. Sternocleidomastoid muscle
8. Sternocleidomastoid branch of STA
9. Glandular branch of STA
10. Infrahyoid branch of STA
11. Vagus nerve
12. Superior laryngeal artery

13. Thyroid cartilage
14. Inferior thyroid artery
15. Recurrent laryngeal nerve
16. Zuckerkandle's tubercle
17. External branch of superior laryngeal nerve

Origin of STA in relation to CB

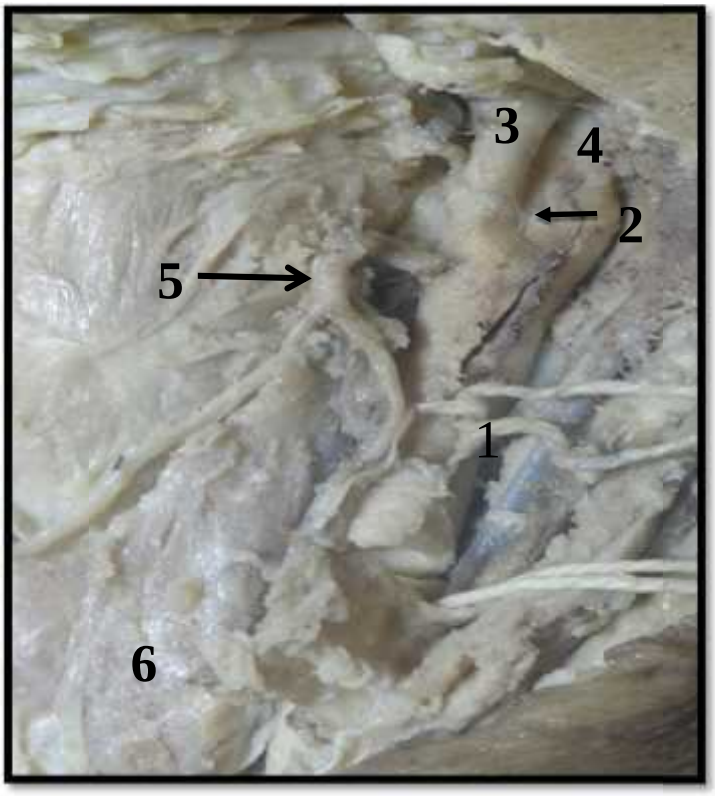


Image 2 –STA origin under the level of CB

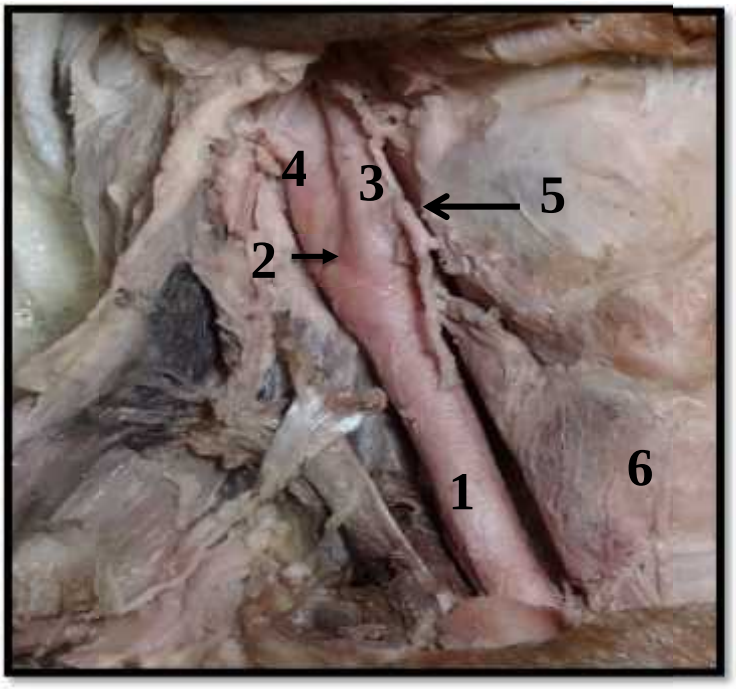


Image 3- STA origin above the level of CB

Origin of STA in relation to CB

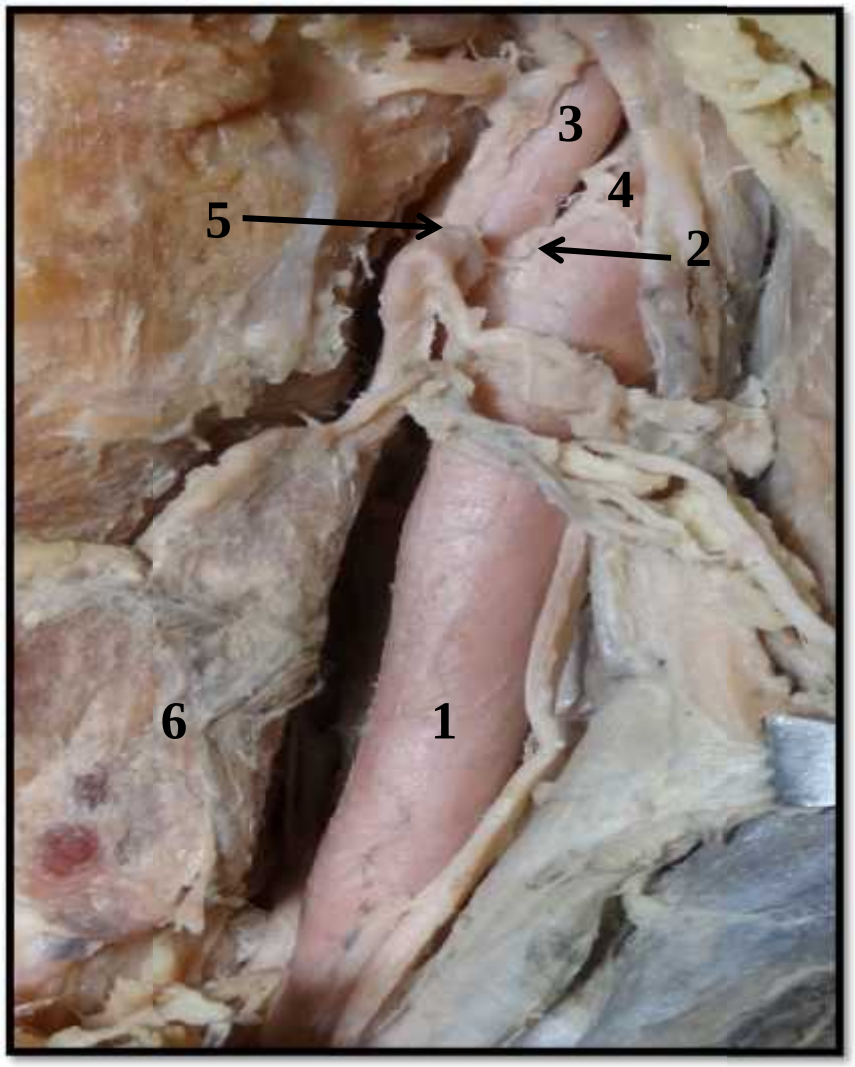


Image 4 – STA origin at same level of CB

Branching pattern of STA

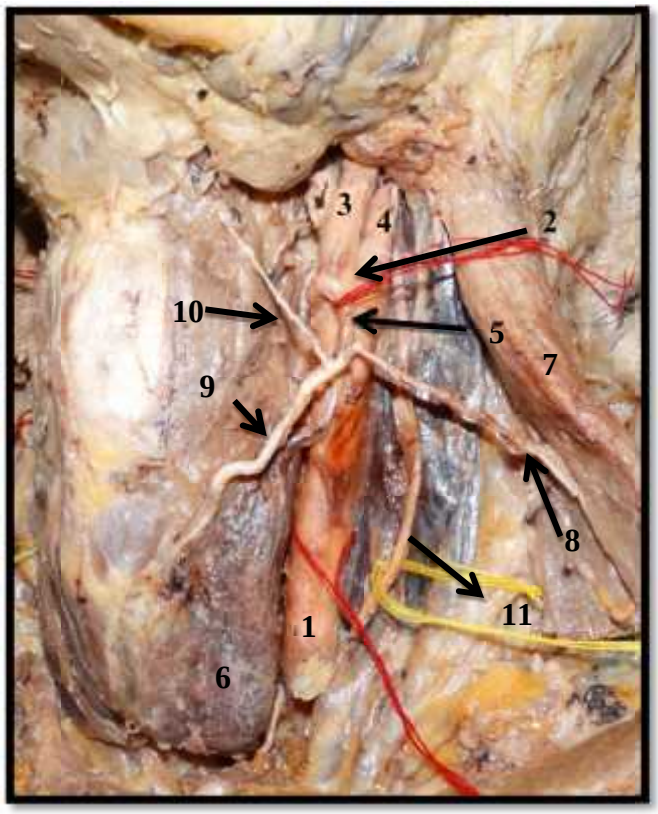


Image 5- type 1

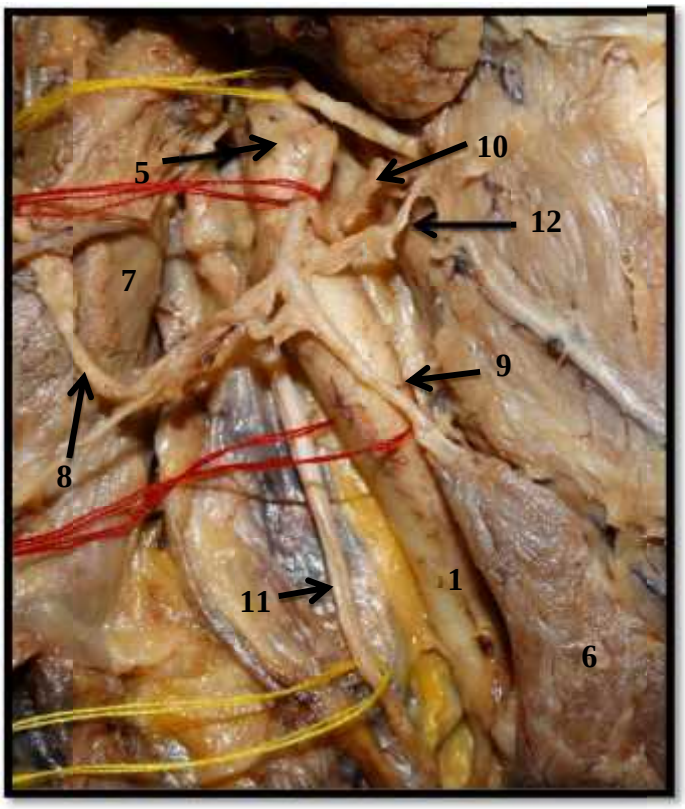


Image 6- Type 2

Branching pattern of STA

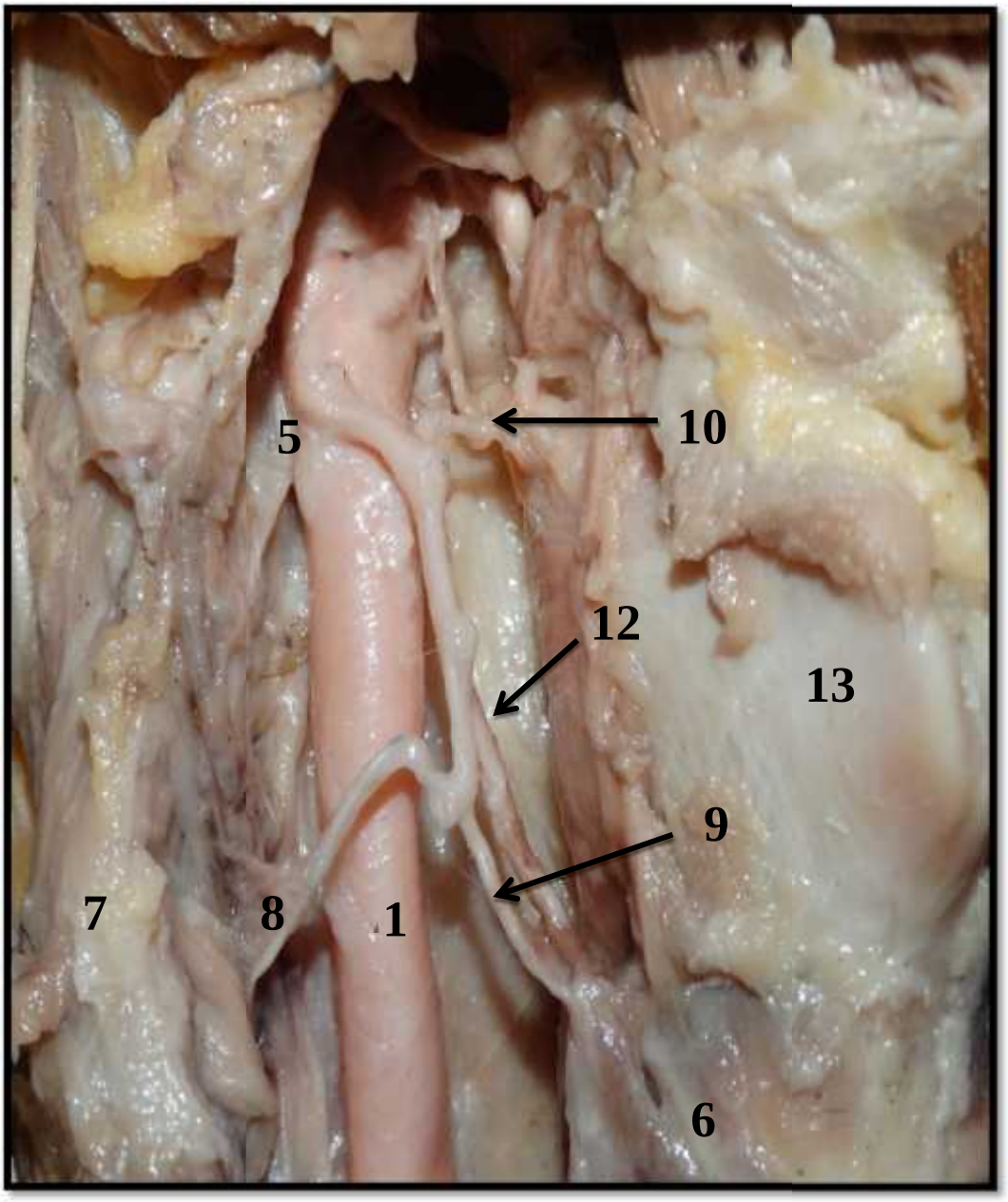


Image 7-Type 3

Topography of RLN in relation to ITA

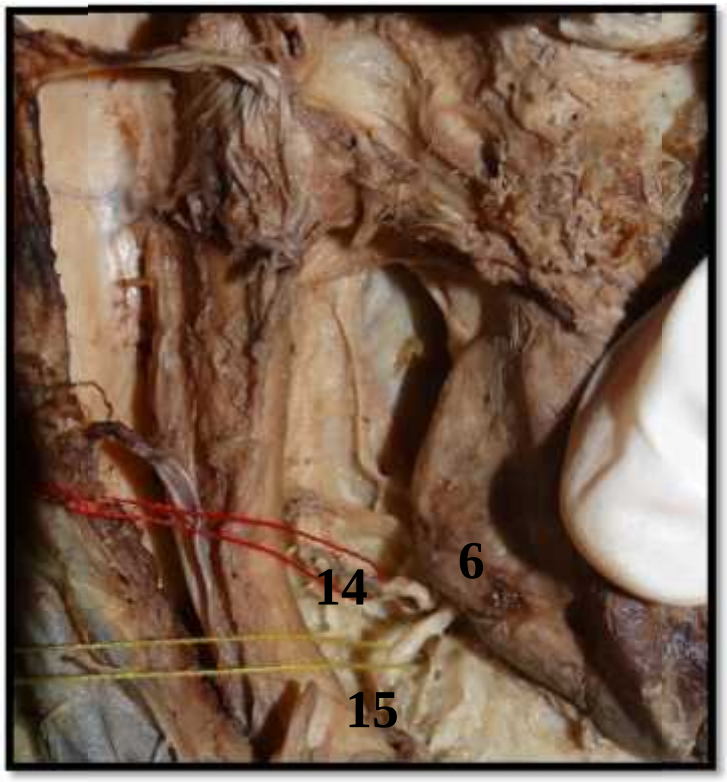


Image 8- RLN anterior to ITA

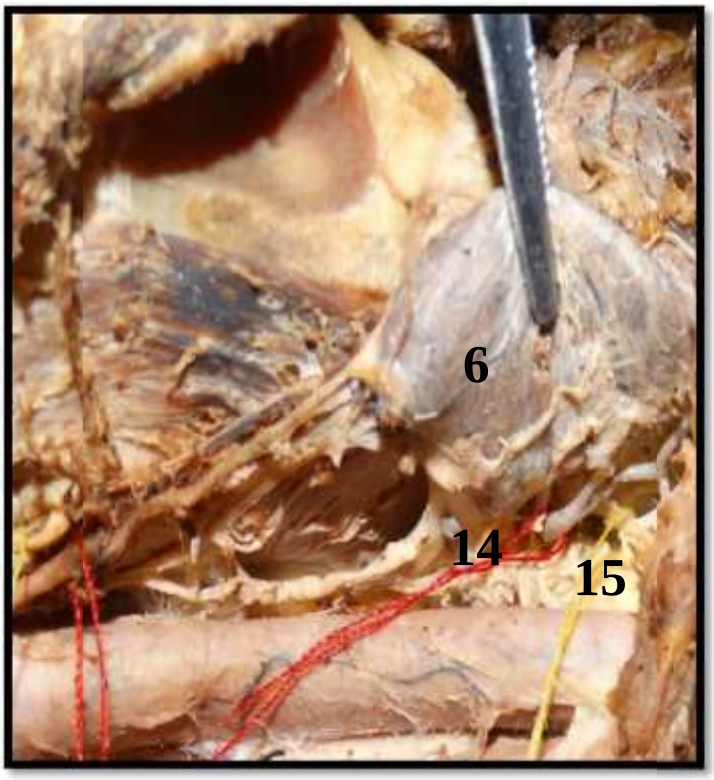


Image 9- RLN posterior to ITA

Topography of RLN in relation to ITA

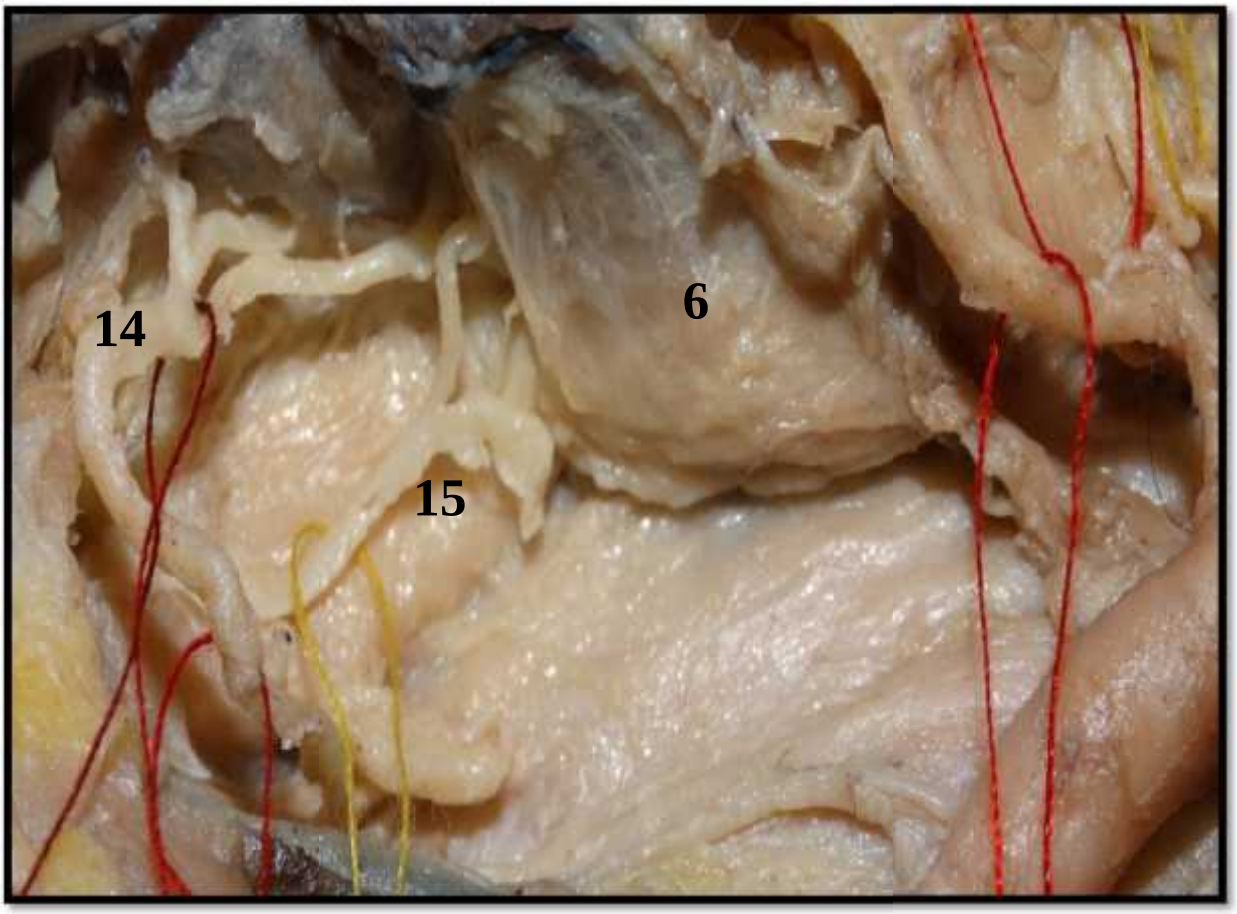


Image 10-RLN in between the branches of ITA

Topography of RLN in relation to ZT

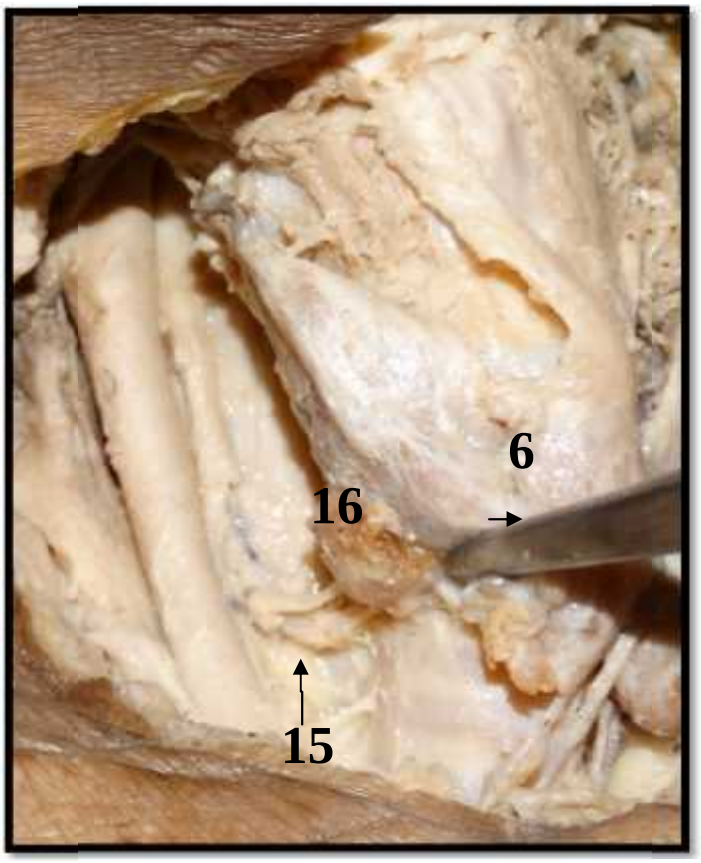


Image 11

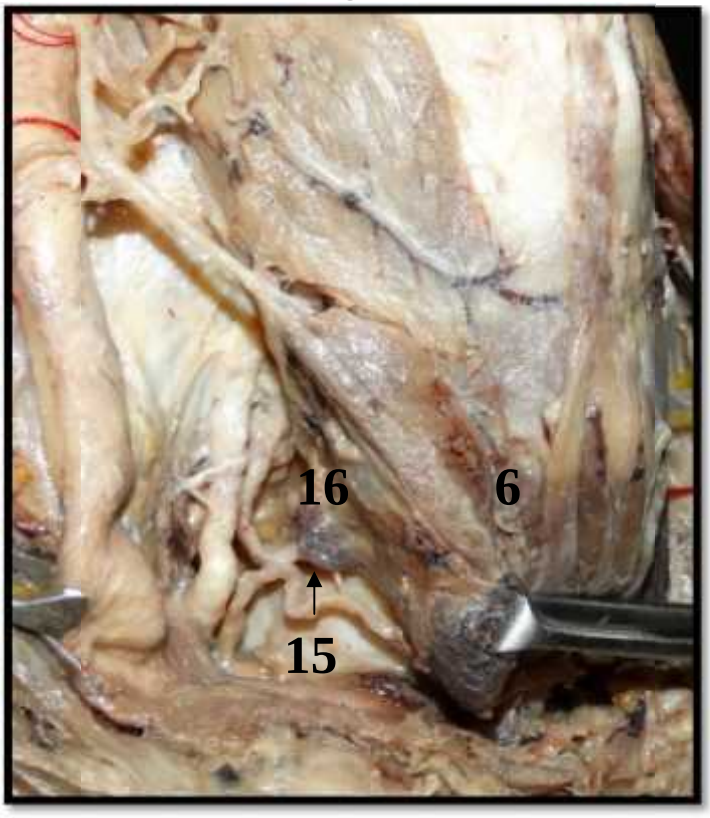


Image 12

Location of EBSLN in relation to STA

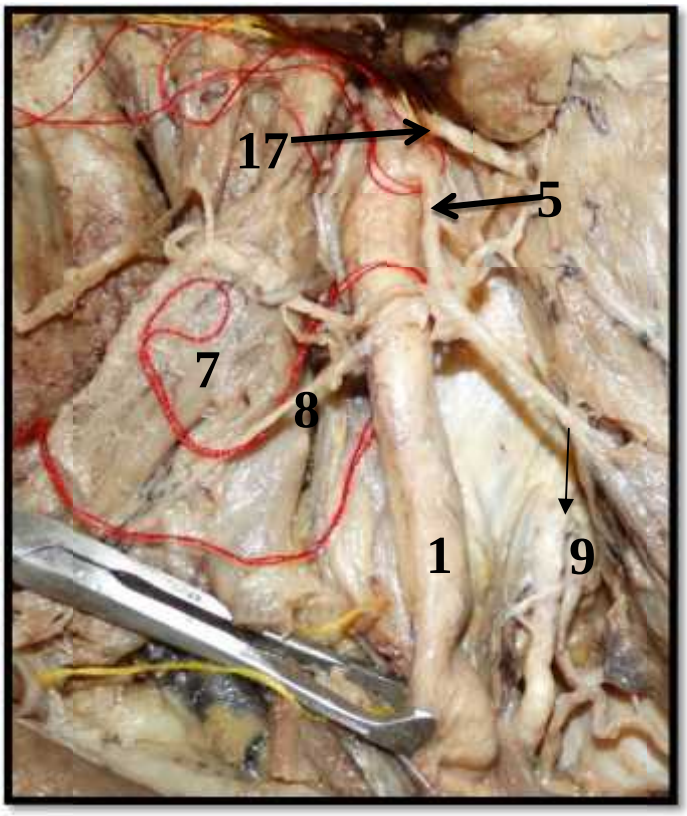


Image 13

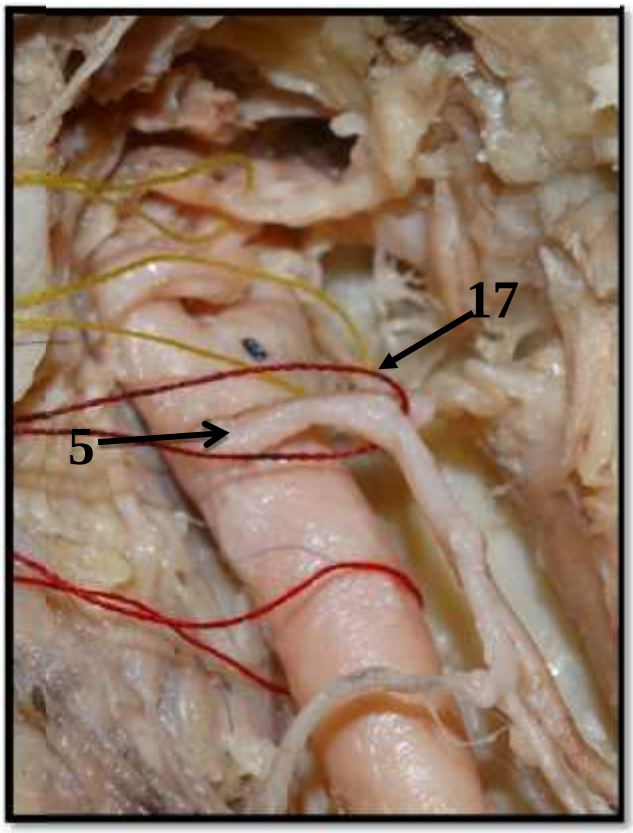


Image 14

ANNEXURE – IV

KEY TO MASTER CHART

F	Female
M	Male
Yrs	Years
STA	Superior Thyroid Artery
CC	Carotid Bifurcation
LA	Lingual Artery
FA	Facial Artery
HN	Hypoglossal Nerve
ECA	External Carotid Artery
CCA	Common Carotid Artery
SLA	Superior Laryngeal Artery
AGB	Anterior Glandular Branch
PGB	Posterior Glandular Branch
ITA	Inferior Thyroid Artery
RLN	Recurrent Laryngeal Nerve
EBSLN	External Branch Of Superior Laryngeal Nerve
LB	Ligament Of Berry
ZT	Zuckerkandl's Tubercle
SP	Superior Parathyroid

S No	Age	Sex	OF THYROID GLAND	SUPERIOR THYROID ARTERY																																		ZUKERKANDLE TUBERCLE	
				DISTANCE OF ORIGIN(mm)												ORIGIN IN RELATION TO CB		ORIGIN IN RELATION TO ECA		ORIGIN IN RELATION TO TC		BRANCHING PATTERN OF STA		LOCATION IN RELATION TO ITA		IN RELATION TO LIGAMENT OF BERRY		IN RELATION TO ZT		IN RELATION TO STA		NUMBER	SUPRANUMBERIC GLAND	DISTANCE BETWEEN ZT AND SP			
				RIGHT						LEFT						RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT			RIGHT	LEFT	RIGHT	LEFT
				CB	LA	FA	SLN	HN	TC	CB	LA	FA	SLN	HN	TC																								
1	54	M	TYPE 4	3.2	7.2	16.2	8.2	18.2	1.2	0.4	8.1	16.4	8.1	18.1	1.4	BELOW	SAME LEVEL	MEDIAL	MEDIAL	SAME LEVEL	SAME LEVEL	TYPE 1	TYPE 1	POSTERIOR	POSTERIOR	DEEP	DEEP	TYPE A	TYPE A	TYPE 2	TYPE 2	4	NIL	0mm	0mm	GRADE 2	GRADE 2
2	81	F	TYPE 2	3.2	6.4	18.2	11.1	19.2	7.2	3.2	6.3	17.8	10.5	20.1	7.4	ABOVE	ABOVE	ANTEROMEDIAL	ANTEROMEDIAL	BELOW	BELOW	TYPE 2	TYPE 2	POSTERIOR	POSTERIOR	DEEP	DEEP	TYPE A	TYPE A	TYPE 1	TYPE 1	4	NIL	0mm	0mm	GRADE 2	GRADE 2
3	75	M	TYPE 2	3.4	7	18.1	9.2	19.1	6.4	3.5	7.2	18.2	9.4	18.8	5.2	ABOVE	ABOVE	MEDIAL	MEDIAL	ABOVE	ABOVE	TYPE 3	TYPE 3	POSTERIOR	POSTERIOR	DEEP	DEEP	TYPE A	TYPE A	TYPE 2	TYPE 2	4	NIL	0mm	0mm	GRADE 2	GRADE 2
4	80	M	TYPE 2	0.4	6.2	9.2	10.2	18.2	6.4	4.5	6.2	9.4	10.1	18.4	6.6	SAME LEVEL	ABOVE	MEDIAL	MEDIAL	ABOVE	ABOVE	TYPE 1	TYPE 1	POSTERIOR	BETWEEN	SUPERFICIAL	SUPERFICIAL	TYPE A	TYPE A	TYPE 1	TYPE 1	4	NIL	<5mm	<5mm	GRADE 2	GRADE 2
5	72	M	TYPE 4	4.2	6.2	12.2	9.2	18.1	6.4	4.4	6.7	12.4	8.4	18.2	6.8	ABOVE	ABOVE	MEDIAL	MEDIAL	ABOVE	ABOVE	TYPE 2	TYPE 2	POSTERIOR	POSTERIOR	SUPERFICIAL	DEEP	TYPE A	TYPE A	TYPE 2	TYPE 2	4	NIL	<5mm	<5mm	GRADE 2	GRADE 2
6	83	M	TYPE 2	4.4	6.4	12.2	8.2	19.2	6.4	4.6	6.4	12.1	8.4	18.9	7.2	ABOVE	ABOVE	MEDIAL	MEDIAL	ABOVE	ABOVE	TYPE 1	TYPE 2	POSTERIOR	POSTERIOR	SUPERFICIAL	DEEP	TYPE A	TYPE A	TYPE 2	TYPE 2	4	NIL	<5mm	<5mm	GRADE 2	GRADE 2
7	93	M	TYPE 4	3.2	6.3	8.2	10.12	9.18	2.7	3.4	6.6	8.1	9.12	9.9	2.2	BELOW	BELOW	MEDIAL	MEDIAL	SAME LEVEL	SAME LEVEL	TYPE 1	TYPE 1	BETWEEN	POSTERIOR	SUPERFICIAL	SUPERFICIAL	TYPE A	TYPE A	TYPE 1	TYPE 2	4	NIL	0mm	0mm	GRADE 1	GRADE 1
8	92	M	TYPE 4	4.27	6.2	11.6	8.95	18.1	3.47	1.2	5.2	12.1	9.77	18.2	4.1	ABOVE	SAME LEVEL	MEDIAL	MEDIAL	ABOVE	SAME LEVEL	TYPE 1	TYPE 2	POSTERIOR	POSTERIOR	SUPERFICIAL	SUPERFICIAL	TYPE D	TYPE D	TYPE 2	TYPE 2	4	NIL	0mm	<5mm	GRADE 2	GRADE 2
9	86	M	TYPE 2	2.2	10.2	14.2	9.2	19.2	7.2	4.4	10.1	14.8	9.4	19.8	7.4	SAME LEVEL	ABOVE	MEDIAL	MEDIAL	SAME LEVEL	ABOVE	TYPE 1	TYPE 2	POSTERIOR	POSTERIOR	SUPERFICIAL	SUPERFICIAL	TYPE A	TYPE A	TYPE 2	TYPE 2	4	NIL	0mm	<5mm	GRADE 1	GRADE 1
10	106	F	TYPE 6	5.2	9.2	16.2	7.2	18.2	6.7	5.1	9.8	17.1	8.1	18.8	6.8	ABOVE	ABOVE	MEDIAL	MEDIAL	ABOVE	ABOVE	TYPE 1	TYPE 1	POSTERIOR	POSTERIOR	DEEP	DEEP	TYPE D	TYPE D	TYPE 2	TYPE 2	4	NIL	<5mm	<5mm	GRADE 2	GRADE 2
11	60	F	TYPE 4	4	7.2	16.1	7.4	18.2	6.2	1.5	7.4	16.2	7.5	18.2	6.2	BELOW	SAME LEVEL	MEDIAL	MEDIAL	ABOVE	ABOVE	TYPE 1	TYPE 1	POSTERIOR	POSTERIOR	DEEP	DEEP	TYPE A	TYPE A	TYPE 2	TYPE 2	4	NIL	0mm	<5mm	GRADE 1	GRADE 1
12	65	F	TYPE 2	3.2	6.4	18.5	11.4	19.6	7.2	3.2	6.4	18.1	11.6	20.1	7.4	ABOVE	ABOVE	ANTEROMEDIAL	ANTEROMEDIAL	BELOW	BELOW	TYPE 2	TYPE 2	POSTERIOR	POSTERIOR	THROUGH	THROUGH	TYPE A	TYPE D	TYPE 1	TYPE 1	4	NIL	<5mm	<5mm	GRADE 1	GRADE 1
13	83	M	TYPE 2	3.2	7.2	18.2	9.2	19.2	6.4	3.5	7.1	18.4	9.2	19.4	5.2	ABOVE	ABOVE	MEDIAL	MEDIAL	ABOVE	ABOVE	TYPE 3	TYPE 3	POSTERIOR	POSTERIOR	SUPERFICIAL	DEEP	TYPE D	TYPE D	TYPE 2	TYPE 2	4	NIL	0mm	0mm	GRADE 2	GRADE 2
14	61	F	TYPE 2	4.4	6.2	9.2	10.2	18.2	6.4	4.5	6.2	9.4	10.1	18.4	6.6	SAME LEVEL	ABOVE	MEDIAL	MEDIAL	ABOVE	ABOVE	TYPE 1	TYPE 1	POSTERIOR	BETWEEN	DEEP	DEEP	TYPE A	TYPE A	TYPE 1	TYPE 1	4	NIL	0mm	<5mm	GRADE 2	GRADE 2
15	75	M	TYPE 4	4.4	6.8	12.2	9.2	18.2	6.4	4.4	6.7	12.6	8.4	18.4	6.8	ABOVE	ABOVE	MEDIAL	MEDIAL	ABOVE	ABOVE	TYPE 2	TYPE 2	POSTERIOR	POSTERIOR	SUPERFICIAL	DEEP	TYPE A	TYPE A	TYPE 2	TYPE 2	4	NIL	<5mm	<5mm	GRADE 1	GRADE 1
16	83	M	TYPE 2	4.2	6.8	12.4	8.2	19.6	6.4	4.4	6.4	12.6	8	19.1	7	ABOVE	ABOVE	MEDIAL	MEDIAL	ABOVE	ABOVE	TYPE 1	TYPE 1	POSTERIOR	POSTERIOR	THROUGH	THROUGH	TYPE A	TYPE A	TYPE 2	TYPE 2	4	NIL	<5mm	<5mm	GRADE 2	GRADE 2
17	83	M	TYPE 4	3.2	6.2	8.2	10.12	9.28	2.7	3.4	6.4	8.1	9.8	9.9	2.2	BELOW	BELOW	MEDIAL	MEDIAL	SAME LEVEL	SAME LEVEL	TYPE 1	TYPE 1	BETWEEN	POSTERIOR	SUPERFICIAL	SUPERFICIAL	TYPE A	TYPE A	TYPE 1	TYPE 2	4	NIL	<5mm	<5mm	GRADE 1	GRADE 1
18	70	M	TYPE 4	4.2	6.2	11.7	8.95	18.2	3.47	1.2	5.6	12.1	9.77	18.4	1.4	ABOVE	SAME LEVEL	MEDIAL	MEDIAL	ABOVE	SAME LEVEL	TYPE 1	TYPE 2	POSTERIOR	POSTERIOR	DEEP	DEEP	TYPE A	TYPE A	TYPE 2	TYPE 2	4	NIL	0mm	0mm	GRADE 2	GRADE 2
19	66	M	TYPE 2	1.2	10.2	14.2	9.2	19.2	1.4	4.4	10.1	14.8	9.4	19.8	5.4	SAME LEVEL	ABOVE	MEDIAL	MEDIAL	SAME LEVEL	ABOVE	TYPE 1	TYPE 2	POSTERIOR	POSTERIOR	DEEP	DEEP	TYPE D	TYPE D	TYPE 2	TYPE 2	4	NIL	0mm	<5mm	GRADE 1	GRADE 1
20	74	M	TYPE 8	1	10.6	18.2	8.2	19.6	6.2	1	11.2	18.4	8.4	19.4	6.4	SAME LEVEL	SAME LEVEL	ANTEROMEDIAL	ANTEROMEDIAL	BELOW	BELOW	TYPE 2	TYPE 2	POSTERIOR	POSTERIOR	DEEP	DEEP	TYPE A	TYPE A	TYPE 2	TYPE 2	4	NIL	0mm	<5mm	GRADE 2	GRADE 2
21	69	M	TYPE 8	6.4	8.2	17.2	8.2	19.2	2	6.2	8.4	16.4	8.1	19.1	2	BELOW	BELOW	ANTERIOR	ANTEROMEDIAL	SAME LEVEL	SAME LEVEL	TYPE 1	TYPE 1	POSTERIOR	BETWEEN	DEEP	DEEP	TYPE A	TYPE A	TYPE 1	TYPE 1	4	NIL	0mm	0mm	GRADE 2	GRADE 2
22	60	M	TYPE 2	2	14.2	16	9.2	18.2	4	2	14.2	16.2	9.4	18	4	SAME LEVEL	SAME LEVEL	ANTEROMEDIAL	ANTEROMEDIAL	BELOW	BELOW	TYPE 2	TYPE 2	POSTERIOR	POSTERIOR	DEEP	DEEP	TYPE A	TYPE A	TYPE 2	TYPE 2	4	NIL	<5mm	<5mm	GRADE 1	GRADE 1
23	65	F	TYPE 4	6	7.4	17.2	8.6	19.1	4	6.2	8.1	16.8	8.1	19	4	BELOW	BELOW	MEDIAL	MEDIAL	BELOW	BELOW	TYPE 1	TYPE 1	ANTERIOR	POSTERIOR	SUPERFICIAL	SUPERFICIAL	TYPE A	TYPE A	TYPE 2	TYPE 2	4	NIL	<5mm	0mm	GRADE 2	GRADE 2
24	77	M	TYPE 2	4.2	6.2	15.1	8.2	16.2	4.2	4.2	6.8	15	8	16.1	4	ABOVE	ABOVE	MEDIAL	MEDIAL	BELOW	BELOW	TYPE 1	TYPE 1	POSTERIOR	POSTERIOR	DEEP	DEEP	TYPE D	TYPE D	TYPE 2	TYPE 2	4	NIL	0mm	<5mm	GRADE 2	GRADE 2
25	75	M	TYPE 4	1.5	7.2	15.1	7.2	16.2	2	1.5	7.8	15.4	7.4	16.4	2	SAME LEVEL	SAME LEVEL	MEDIAL	MEDIAL	SAME LEVEL	SAME LEVEL	TYPE 1	TYPE 1	POSTERIOR	POSTERIOR	SUPERFICIAL	SUPERFICIAL	TYPE A	TYPE A	TYPE 2	TYPE 1	4	NIL	0mm	<5mm	GRADE 1	GRADE 1
26	87	M	TYPE 2	2	8.1	16.2	7.8	19.2	4.2	2	8.2	16.4	7.4	19.4	4.1	SAME LEVEL	SAME LEVEL	MEDIAL	MEDIAL	ABOVE	ABOVE	TYPE 2	TYPE 2	POSTERIOR	POSTERIOR	SUPERFICIAL	SUPERFICIAL	TYPE A	TYPE A	TYPE 2	TYPE 2	4	NIL	0mm	0mm	GRADE 1	GRADE 1
27	81	F	TYPE 2	0.5	5.4	14.2	6.2	19.2	4	0.5	5.6	14.4	6.4	18.8	4	SAME LEVEL	SAME LEVEL	MEDIAL	MEDIAL	BELOW	BELOW	TYPE 2	TYPE 2	POSTERIOR	POSTERIOR	SUPERFICIAL	SUPERFICIAL	TYPE A	TYPE A	TYPE 1	TYPE 1	4	NIL	0mm	<5mm	GRADE 2	GRADE 2
28	69	M	TYPE 8	0.5	10.2	17.2	8.2	19.2	6.2	0.5	10.6	17.6	8.4	19.4	6.4	SAME LEVEL	SAME LEVEL	ANTEROMEDIAL	ANTEROMEDIAL	BELOW	BELOW	TYPE 2	TYPE 2	POSTERIOR	POSTERIOR	DEEP	SUPERFICIAL	TYPE A	TYPE D	TYPE 2	TYPE 2	4	NIL	<5mm	0mm	GRADE 2	GRADE 2
29	89	M	TYPE 8	6.2	8.1	16.2	9.2	18.2	2	6.4	8.6	16.4	9.2	18.4	2	BELOW	BELOW	ANTERIOR	ANTEROMEDIAL	SAME LEVEL	SAME LEVEL	TYPE 1	TYPE 1	POSTERIOR	BETWEEN	THROUGH	THROUGH	TYPE D	TYPE D	TYPE 1	TYPE 1	4	NIL	<5mm	<5mm	GRADE 1	GRADE 1
30	55	F	TYPE 2	2	15.1	16.2	8.2	19.1	4	2	15.4	16.6	8.4	19.2	4	SAME LEVEL	SAME LEVEL	ANTEROMEDIAL	ANTEROMEDIAL	BELOW	BELOW	TYPE 2	TYPE 2	POSTERIOR	POSTERIOR	DEEP	DEEP	TYPE A	TYPE A	TYPE 2	TYPE 2	4	NIL	<5mm	0mm	GRADE 2	GRADE 2
31	39	F	TYPE 4	6.2	8.2	18.2	8.6	20.2	4.2	6.4	8.4	18.4	8.1	20.1	4.1	BELOW	BELOW	MEDIAL	MEDIAL	BELOW	BELOW	TYPE 1	TYPE 1	ANTERIOR	POSTERIOR	SUPERFICIAL	SUPERFICIAL	TYPE A	TYPE A	TYPE 2	TYPE 2	4	NIL	<5mm	<5mm	GRADE 2	GRADE 2
32	86	F	TYPE 2	4.2	6.2	16.2	7.2	18.1	3.8	4	6.8	16.4	7.4	18.2	4	ABOVE	ABOVE	MEDIAL	MEDIAL	BELOW	BELOW	TYPE 1	TYPE 1	POSTERIOR	POSTERIOR	DEEP	DEEP	TYPE D	TYPE A	TYPE 2	TYPE 2	4	NIL	0mm	0mm	GRADE 1	GRADE 1
33	65	F	TYPE 4	0.2	7.2	16.4	8.1	19.2	2	0.2	7.4	16.2	8.2	19.4	2	SAME LEVEL	SAME LEVEL	MEDIAL	MEDIAL	SAME LEVEL	SAME LEVEL	TYPE 1	TYPE 1	POSTERIOR	POSTERIOR	THROUGH	THROUGH	TYPE A	TYPE A	TYPE 1	TYPE 1	4	NIL	0mm	0mm	GRADE 2	GRADE 2
34	80	M	TYPE 2	0.6	8.2	16.2	6.4	18.6	4.3	0.6	8.4	16.4	6.5	18.8	4.1	SAME LEVEL	SAME LEVEL	MEDIAL	MEDIAL	ABOVE	ABOVE	TYPE 2	TYPE 2	POSTERIOR	POSTERIOR	DEEP	DEEP	TYPE A	TYPE D	TYPE 2	TYPE 2	4	NIL	0mm	0mm	GRADE 1	GRADE 1
35	72	M	TYPE 2	0.5	5.6	14.4	7.2	19.2	4	0.5	5.8	14.8	7.4	19.1	4	SAME LEVEL	SAME LEVEL	MEDIAL	MEDIAL	BELOW	BELOW	TYPE 2	TYPE 2	POSTERIOR	BETWEEN	DEEP	DEEP	TYPE A	TYPE A	TYPE 1	TYPE 1	4	NIL	0mm	0mm	GRADE 1	GRADE 1
36	82	F	TYPE 4	5.2	9.2	16.2	7.2	18.2	6.7	5.1	9.8	17.1	8.1	18.8	6.8	ABOVE	ABOVE	MEDIAL	MEDIAL	ABOVE	ABOVE	TYPE 1	TYPE 1	POSTERIOR	POSTERIOR	SUPERFICIAL	SUPERFICIAL	TYPE A	TYPE A	TYPE 2	TYPE 2	4	NIL	0mm	0mm	GRADE 2	GRADE 2
37	68	M	TYPE 4	0.2	7.2	14.3	8.2	17.5	1	0.2	7.8	14.2	8.1	17.3	2	SAME LEVEL	SAME LEVEL	ANTEROMEDIAL	ANTEROMEDIAL	SAME LEVEL	SAME LEVEL	TYPE 1	TYPE 1	POSTERIOR	BETWEEN	SUPERFICIAL	SUPERFICIAL	TYPE A	TYPE A	TYPE 1	TYPE 1	4	NIL	0mm	0mm	GRADE 2	GRADE 2
38	65	F	TYPE 2	3.2	6.8	14.2	8.2	22.1	3.2	3.4	6.9	14.3	8.1	22.2	3.4	ABOVE	ABOVE	MEDIAL	MEDIAL	ABOVE	ABOVE	TYPE 2	TYPE 2	POSTERIOR	POSTERIOR	SUPERFICIAL	SUPERFICIAL	TYPE A	TYPE A	TYPE 1	TYPE 1	4	NIL	0mm	0mm	GRADE 2	GRADE 2
39	68	M	TYPE 6	4.2	7.2	7.8	4.2	18.2	4	4.4	7.1	8	4.4	18.6	4	BELOW	BELOW	ANTEROMEDIAL	ANTEROMEDIAL	SAME LEVEL	SAME LEVEL	TYPE 1	TYPE 1	POSTERIOR	BETWEEN	THROUGH	THROUGH	TYPE A	TYPE A	TYPE 1	TYPE 1	4	NIL	0mm	0mm	GRADE 2	GRADE 2
40	65	M	TYPE 8	0.5	7.2	16.2	6.2	20.1	2	0.5	7.5	16.4	6.4	20.3	2	SAME LEVEL	SAME LEVEL	MEDIAL	MEDIAL	SAME LEVEL	SAME LEVEL	TYPE 1	TYPE 1	POSTERIOR	POSTERIOR	SUPERFICIAL	SUPERFICIAL	TYPE A	TYPE A	TYPE 2	TYPE 2	4	NIL	0mm	0mm	GRADE 2	GRADE 2