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CLINICAL STUDY

Analysis of the arterial anatomical variations of thyroid gland: anatomic guide for surgical neck dissection

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Abstract: *Purpose:* Aim of this study was to establish preliminary data on the variations of arterial supply of thyroid gland in Karnataka population.
Methods: The anterior triangles in the neck of formalin fixed cadavers were dissected. The length, branching pattern, number and length of branches of superior thyroid artery (STA) were noted. We measured the length of inferior thyroid artery (ITA) from its point of emergence from thyrocervical trunk (TCT) to lower pole of thyroid gland. The length of the external carotid artery (ECA), TCT from the point of its emergence to the point of its branching was noted. We noted the number of branches from ITA and TCT. Presence of any additional artery supplying the thyroid gland was searched for. Difference in the length of STA and ITA between the two sexes and sides were noted. Statistical analysis was done by Student's t-test.
Results: In our study the maximum length of STA was 5.34cm and that of ITA was 5.07cm and there were no statistically significant side-to-side differences in level of bifurcation.
Conclusions: Observations of the present study on the course and branching pattern of arteries around thyroid gland will help in easier approach during thyroid surgeries and interventional techniques *(Tab. 1, Fig. 3, Ref. 38)*. Full Text in PDF *www.elis.sk.*
Key words: superior thyroid artery, inferior thyroid artery, thyroid gland, external carotid artery, common carotid artery, thyrocervical trunk.

The arteries supplying the thyroid gland are STA and ITA and sometimes a thyroid ima artery (TIA) from the brachiocephalic trunk or aortic arch (1) (Fig. 1). Yilmaz et al have reported an anomaly in which both ITAs were absent and were replaced by ATI which originated from the brachiocephalic trunk and bifurcated immediately almost after its origin (2).

The STA, as per the anatomic literature, is usually the first anterior branch of ECA arising at the level of the bifurcation. However, variations in the origin have been reported for this artery, including its origin from CCA or from the carotid arterial tree in common with other arterial trunks (3). The STA is frequently used as a recipient vessel for microvascular free tissue transfer in head and neck surgery, for selective embolization of thyroid or head and neck tumors and also as a landmark for identifying the superior laryngeal nerve in thyroid surgery (4, 5). Consequently, it is important to have a clear understanding of variations in the anatomy of this artery.

The ITA arises from TCT which is a branch of the first part of the subclavian artery (1). It loops upwards anterior to the medial border of the scalenus anterior, turns medially just below the

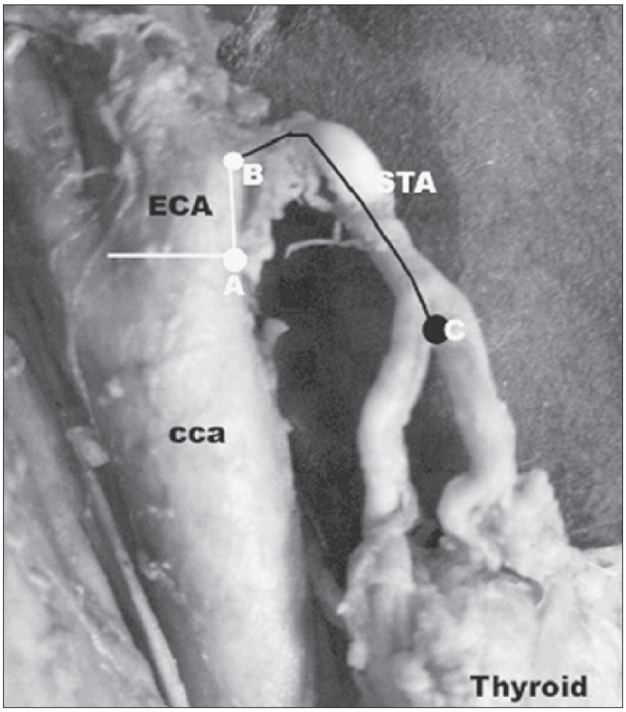

Fig. 1. Photograph showing the morphometry of length of ECA from its point of emergence from CCA (point A) to its point of emergence of STA (point B) and length of STA from its point of emergence from ECA (point B) to its branching (point C).

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sixth cervical transverse process, then descends on longus colli muscle to the lower border of the thyroid gland. It passes anterior to the vertebral vessels and posterior to the carotid sheath. On the left side, near its origin, the artery is crossed anteriorly by the thoracic duct as the latter curves inferolaterally to its termination (6). Operative treatment involving this artery may be required in thyroid carcinomas or other thyroid tumors (7). Because the thyroid gland is well vascularized, the dissection and cutting of the thyroid vessels is an essential part of every thyroid operation. STA being phylogenetically older, is relatively stable as compared to ITA, which is more variable (8, 9). Additionally, the recurrent laryngeal nerve crossing with ITA is often considered to be the most vulnerable location while performing thyroidectomy because of the close nerve-artery relations at this site (10, 11). Therefore, a detailed knowledge of anatomical variations of this artery can help in avoiding the surgical complications (12).

TIA which is a small and inconstant branch ascends on the trachea and ends by supplying the thyroid isthmus. It may arise from the brachiocephalic trunk, aorta, subclavian or internal thoracic arteries (1).

Although the data about anatomic variations of these arteries have been published, they are complex and elaborate. They are based on either the number of collateral branches arising from STA or more frequently, on the number and relative position of the collateral branches of ECA (9). In literature surveyed, the data based exclusively on specific origin of STA or ITA were scanty. The clinical diagnosis and surgical procedures require a thorough knowledge not only of the normal gross anatomy of structures within the region but also of the anatomical variations of structures located within it. Recent and continuous advances in surgical procedures have made the need for such detailed knowledge ever more important. Furthermore, some angiographic procedures require more complete quantitative information about certain parameters, including the diameters of their branches and distances of the origins of these arteries from carotid bifurcation (13). The present article describes variations in normal anatomy, morphometry and branching pattern of STA, ITA and TIA.

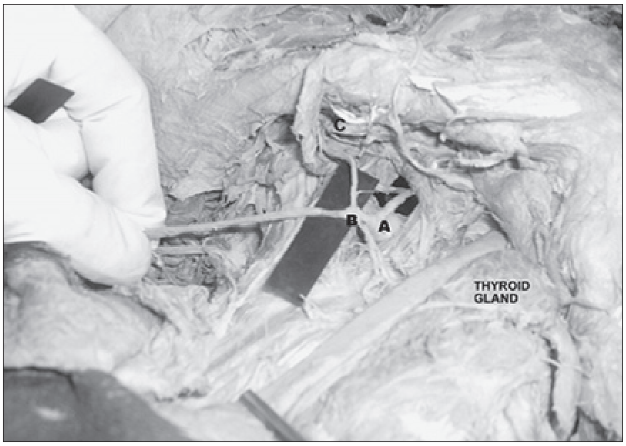

Fig. 2. Photograph showing the morphometry of length of TCT from its point of emergence to its branching (point AB) and length of ITA from its point of emergence to its point of branching at lower pole of thyroid gland (point BC).

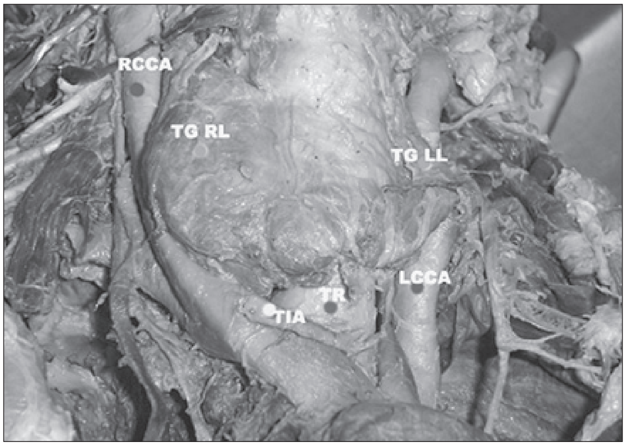

Fig. 3. Photograph showing the thyroidea ima artery (TIA) arising from right CCA (RCCA) and supplying the left lobe of the thyroid gland (TG LL) crossing superficial to trachea (TR). Left CCA (LCCA) and right lobe of the thyroid gland (TG RL) are also labelled. ECA – external carotid artery, ICA – internal carotid artery, RCCA – right common carotid artery, TIA – thyroidea ima artery, TG RL – thyroid gland right lobe).

Materials and methods

Materials

Twenty-five (13 male and 12 female) formalin-fixed cadavers aged between 50 to 60 years were examined in total. None of the cadavers had the history of vascular surgical intervention. The origin and number of branches of STA and ITA and any other variations in arteries supplying the thyroid gland were noted. The distances were measured with calipers. Statistical comparisons were made using the Student-T test, with a value of $p<0.05$ taken as a statistically significant one. Previously published results were carefully reviewed and compared to present a meta-analysis and from the results in the present study, a unified and simple classification is proposed.

Methods

The length of ECA from its point of emergence from CCA (point A) to its point of emergence of STA (point B) was measured. The length of STA from its point of emergence from ECA (point B) to its branching (point C) was measured. Numbers of branches of STA were noted (Fig. 2).

The length of TCT from its point of emergence to its branching was measured (point AB). The length of ITA from its point of emergence to its point of branching at lower pole of thyroid gland was measured (point BC) (Fig. 3). Numbers of branches of TCT were noted.

Presence of any additional artery supplying thyroid gland was looked for.

Results

Length, width, branching pattern and number of branches of STA, ITA and TCT in both sexes and both sides were observed, compared and tabulated. Measuring the length of STA, ITA and TCT in both sexes and on both sides (right and left) revealed that

Tab. 1. Measuring the length of STA, ITA and TCT in both sexes and on both sides.

Result	Male		Female	
	Right (cm)	Left (cm)	Right (cm)	Left (cm)
STA	3.8 ±0.70	5.34 ± 1.06	2.67 ± 1.60	2.75 ± 1.69
ECA	0.3 ± 0	0.5 ± 0.49	0.24 ± 0.07	0.3 ± 0.07
ITA	5.03± 0.02	5.07± 0.12	4.93± 0.58	4.94± 1.23
TCT	0.9± 0.28	0.48± 0.04	0.69± 0.14	0.52± 0.07

longer arteries were observed in males on left side (Tab. 1). There were no statistically significant side-to-side differences in level of bifurcation ($p>0.05$).

The mean number of branches from STA and ITA was found to be 3.

In 1 cadaver, TIA arose from right CCA and supplied the left lobe of the thyroid gland by crossing the trachea superficially.

Discussion

The knowledge of anatomy of normal and variant arterial supply of the thyroid gland is important during surgical treatment of the upper larynx, parathyroid and thyroid glands. Most anatomists, angiologists and head and neck surgeons are familiar with the variations in the origin and course of the principal arteries of the thyroid gland. The origins of STA, ITA and TCT could be categorized depending upon differences in their length in genders and on the two sides depending upon their site of origin from the carotid arterial tree.

Superior thyroid artery

The morphology and embryology of STA have been mentioned in previous literature (14). In our study, the maximum mean length of STA was found in male on the left side and there were no statistically significant side-to-side differences. Our results were consistent with the report of Ozgur et al from Turkey (15). A frequently reported pattern of origin of STA describes it as arising from ECA. Differences in the origin in sexes and sides have been described previously for STA. The origin of left STA was described to be at a lower level than on the right (4). The origin of artery from CCA was described with a higher frequency on the left side and in women, though the present study provides no quantitative results to support these statements (16). In our results, only statistically significant differences in origin with respect to two sides have been observed with STA arising from CCA with a higher frequency on the left side and in males. This study also highlights that STA may not be considered as a constant surgical landmark (Tab. 1).

The morphometry and branching pattern of STA plays an important role in intra-arterial infusion chemotherapy for laryngeal and hypopharyngeal cancers (17). STA has a major role in flow patterns and wall shear stress in the carotid bifurcation (18). Reversed flow STA can serve as an alternative recipient vessel in head and neck reconstruction (19). Lack of prior knowledge about variations of STA may lead injuring the artery during neck surgery (20). During thyroid gland surgery, STA should be ligated close to the gland since this artery is accompanied by the external laryngeal nerve posteromedial to it (1). Ruptured STA during central vein cannulation can be treated by coil embolization (21). When ITA is ligated, STA assumes the function of supplying both pairs of parathyroid glands via the anastomotic branch connecting the two arteries (22).

Inferior thyroid artery

ITA has a variable branching pattern and is closely associated with the recurrent laryngeal nerve. The nerve can be found deep to ITA, superficially or between branches of the artery (23). Furthermore, at the level of ITA extralaryngeal branches of the recurrent laryngeal nerve may be present. It may be more variable or even could be absent (24–27). This is the first reported study of variation in the lengths of ITA and TCT. The number of branches of TCT was observed to be consistent with Daseler and Anson (28). Lucev et al reported that the branching of CCA acts as a key landmark for adequate and appropriate placement of the cross-clamp on carotid arteries (29). In the present study, ITA arose as a single trunk from TCT in 5 males and 7 females and as multiple branches it was observed in 8 males and 5 females. The incidence of multiplication is more in the males. The variations in the ramifications of both the subclavian and ECA are not very rare and hence they are essential for the surgical and diagnostic procedures in the neck region (30). For this reason, the variations of the thyroid arteries require special attention.

Preservation of all the branches is important during thyroidectomy while ligating the regional vessels (31). The variation should also be borne in mind during ITA catheterization for diagnostic or therapeutic purposes in case of an aneurysm (32). Awareness of these variations and a careful examination is necessary before performing any invasive procedures. The relationship between ITA and recurrent laryngeal nerve has been shown to be helpful in locating the nerve during surgical procedures involving the thyroid gland (33). Palpation and observation of the recurrent laryngeal nerve in the region of ITA near the inferior pole of the lobe of the thyroid gland can reduce the incidence of nerve injury which is reported in 1–6 % of cases in thyroid surgery (34). As an alternative surgical approach, ligation of tertiary branches of ITA at the surface of the thyroid gland, with subsequent identification of the recurrent laryngeal nerve, can aid in protecting the nerve (35).

Thyroidea ima artery

Any anomalous vessel arising from the brachiocephalic trunk, CCA, aortic arch or internal thoracic artery supplying the thyroid gland has been considered an ima artery (1). If the aberrant artery arises from the subclavian, it is generally considered to be an accessory ITA rather than an ima (36, 37). In the present study, we found TIA to arise from right CCA and to pass the left lobe of the thyroid gland after superficially crossing the trachea from right to left side. This uncommon or rare anatomical variation could become clinically significant during tracheostomy.

Conclusion

The knowledge of arterial variations in the neck region may be of great importance in the diagnosis and treatment of cervical pathologies (38). Thus the present study on variations in origin, course and branching pattern of STA, ITA and TCT is important for surgical procedures in the neck region, such as emergency cricothyroidotomy, radical neck dissection, catheterization and reconstruction of aneurysm and carotid endarterectomy

(20). Information about the vascular anatomy of the thyroid gland will minimize chances of complications.

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