“OVIDIUS” UNIVERSITY FROM CONSTANȚA
MEDICAL DOCTORAL SCHOOL
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DOCTORAL THESIS

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CONSTANȚA

2024

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Anatomical features on the arterial vasculature of the thyroid gland

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ABBREVIATIONS USED

AA aortic arch

Aa arteries

ACA ascending cervical artery

BCT brachiocephalic trunk

CCA common carotid artery

CVC central venos cateter

ECA external carotid artery

ICA internal carotid artery

IT internal thoracic artery

ITA inferior thyroid artery

L left

LA lingual artery

R right

RLN recurrent laryngeal nerve

SA subclavian artery

SLN superior laryngeal nerve

STA superior thyroid artery

TCT thyrocervical trunk

TIMA ima thyroid artery

TLF thyrolingofacial trunk

TLT thyrrolingual trunk

TN transverse artery of the neck

TT thyroid trunk

VA vertebral artery

INTRODUCTION

The arterial vasculature of the thyroid gland is extensive because it is an endocrine gland of distinct functional importance, with a role in the body's growth, normal metabolic activity, and mental development. The vessels supplying it are usually the superior and inferior thyroid arteries, which originate from the carotid system and the subclavian artery respectively. Occasionally, another artery may supply the thyroid, the thyroid artery ima.

The risk of damage to the blood vessels during surgery can be minimalized if all anatomical variations and developmental abnormalities are taken into account. Knowledge of these elements focuses on two important aspects: incidence and morphology of arterial variants. In the neck area, the anterior cervical region is the most clinically important and the thyroid gland area must be accurately assessed before any surgery. Dissection and closure of all thyroid arteries and veins is an essential part of any successful thyroidectomy. The different types of variations in the thyroid blood supply should be well understood and documented in medical studies.

Thyroid vessels are involved and have multiple roles in the head and neck surgical procedures. They are frequently used for selective embolization of the thyroid and other head and neck tumors, emergency cricothyroidotomy, radical neck grafting, diagnostic and therapeutic catheterization, plastic surgery, aneurysm reconstruction, carotid endarterectomy, and are a surgical landmark for identification of the external branch of the superior laryngeal nerve in thyroid surgery. Surgical treatments of thyroid disorders are the most common clinical practice. As a consequence, detailed knowledge of the arterial vasculature of this gland in examined subjects is of immense importance to prevent any hemorrhage, which may become alarming.

Variations in the origin and distribution pattern of the STA are of great importance for head and neck surgery because of their vital relationship to the external branch of the SLN, which distributes to the cricothyroid muscle. Because of its close rapport with the STA, the external branch of the SLN is at risk of injury when the artery is ligated. The incidence of nerve injury in patients undergoing thyroidectomy is reported to be up to 58% of surgical cases in thyroid surgery, according to Dessie's statistics.

Angiologists and physicians, especially head and neck surgeons, should be familiar with variations in the origin and course of the main arteries of the head and neck during surgical procedures and treatment of the superior larynx, parathyroid and thyroid glands. Esen recommends a thorough CT angiographic study to understand the arterial system of the head and neck region prior to any surgical approach. Thyroidectomy is the most common head and neck surgery performed worldwide and the mortality rate is considered to be 0%. Although the complication rate is less than 3% (including compressive haematoma, recurrent laryngeal nerve paralysis and hypoparathyroidism), these are very significant in forensic cases. All surgery carries the risk of potentially fatal complications and therefore risks should be considered and minimised in all cases.

STA also participates in the formation of an important collateral circulation, between the external carotid arteries, which becomes important in cases of unilateral common carotid artery occlusion.

Worldwide, the prevalence of goitre is estimated at 12%. Surgical treatment is preferred for most of these patients, as it removes most of the goitre, corrects functional disturbances and removes possible malignant tumours. Because the thyroid gland is well vascularized, dissection and sectioning of the thyroid vessels is an essential part of every thyroid surgery.

Anatomical variations can influence disease susceptibility, symptomatology, investigations and patient management, including the operation process. Consequently, accurate knowledge of variability in human morphology is important to improve diagnostic and interventional performance especially against the background of contemporary imaging techniques such as echocardiography, magnetic resonance imaging, computed tomography, endoscopy; open techniques and laparoscopic surgery. Therefore, knowledge of the anatomical variations of the thyroid gland is essential for thyroid surgical procedures. Correct identification of the thyroid gland vessels is very important to avoid major complications during and after neck surgery.

Some authors, such as Graves, consider ITA to be one of the primary vascular sources of the thyroid gland. ITA is thought to be responsible for thyroid perfusion during fetal development. Of particular importance is the relationship of the ITA to the recurrent laryngeal nerve, which passes anterior to the vertebral artery and posterior to the CCA, thus there is an antero-posterior overlap of three vessels, injury at this level can injure them, followed by severe haemorrhage.

Both normal ITA and its variants are at risk structures during operative procedures in the neck. ITA variations can lead to iatrogenic injury during central venous catheter placement. It has been suggested that ultrasound can be used prior to CVC insertion to identify these aberrant ITAs and avoid unnecessary injury, ITAs can be injured during any neck procedure ranging from carotid endarterectomy, aneurysm repair to thyroidectomy. A detailed knowledge of the vasculature of the thyroid gland, is of paramount importance in preventing complications.

I would like to mention that my personal results have been used in the publication of five "in extenso" articles: two articles published in the journal "Surgical Radiologic Anatomy", ISI and PubMed indexed, impact factor 1.4; two "in extenso" articles were published in "Romanian Journal of Functional and Clinical, Macro- and Microscopic Anatomy and Anthropology", journal of the Romanian Society of Anatomy (B+ and Copernicus indexed journal); one article in "The Medical-Surgical Journal of the Society of Physicians and Naturalists", ISI indexed journal; impact factor 0.6; three papers presented at the national congresses of the Romanian Society of Anatomy with international participation, one in Brasov in 2022, whose abstract was published in the abstract volumes of the congress; two papers presented at the 103rd Congress of the Association of French Morphologists, Annecy 2022 and at the 104th Congress of the Association of French Morphologists, Lille 2023, whose abstracts were published in the abstract volumes of the congress.

AIM OF THE THESIS

In the literature there have been and still are contradictions between authors regarding the origin, trajectory, morphometry (diameter, length) and number of thyroid arteries. The asymmetry (right/left) of the thyroid arteries is generally recognised. In the literature we studied, we did not find any reports of sex-related asymmetries of the thyroid arteries, especially related to morphometry, and there are authors, [Toni], who did not find such asymmetries in their studies. Similarly, many authors do not describe right/left comparative percentages in the same subject.

The aim of my study was to perform a systematic analysis and elucidate in detail the origin of the thyroid artery, reporting any differences according to sex or to the artery on the opposite side, which are highly variable and could be the cause of unnecessary morbidity during interventional procedures in the neck. We particularly emphasized the morphometry and variants of the thyroid arteries because a detailed understanding of the variations and relationships between anatomical structures is the surgeon's best defense in preventing iatrogenic injury. My findings on symmetry, but especially on the asymmetry of the anatomical landmarks pursued in these arteries, are of particular importance in thyroid surgery in particular and in the neck in general. We studied aspects of the level of origin of the thyroid arteries in relation to the carotid artery system, to the BCT or SA origin, to the face of the artery from which they branch, and to the origin of the lingual artery. We followed the decrease in arterial diameter from the origin of the thyroid artery to its termination and the diameter of the artery of origin of the thyroid arteries by measuring the caudal and cranial diameter of the origin of the thyroid artery.

We performed a detailed comparison of the morphological characteristics of the STA, in particular with the morphological characteristics of the ITA, but also of the TIMA, thus being able to determine the contribution of each thyroid artery to the vascularization of the gland.

1. Material and methods

Thyroid arteries were studied using dissection, intravascular injection of plastic mass and CT angiography as working methods.

The dissection was performed on the formalized cadavers in the anatomy laboratory of the Faculty of Medicine in Constanta. For intravascular injection with plastic mass we used Technovitul 7143, of German production, which is a self-polymerizing resin based on methyl methacrylate. The CT examinations were performed on a General Electric Brightspeed Select 16 slice CT scanner, which belongs to the radiology clinic of the Emergency Clinical Hospital "Sf. Apostol Andrei" in Constanta.

The main parameters analysed were represented by the characteristics of the origin of the thyroid arteries, their origin in relation to the origin of the artery from which they originated and in relation to the neighbouring arteries, the symmetry of the arteries (right/left), their course and their mode of termination. The morphometry of the thyroid arteries, their length and diameter was followed in detail. All these morphological landmarks were determined according to the sex of the subject.

Thyroid arteries were followed on a total of 674 cases, 339 cases being male and 335 cases being female. Of the 674 cases, 351 cases were right arteries and 323 cases were left arteries. Most cases were represented by CT angiograms on 348 cases, 222 arteries were observed on dissected cadavers and 104 arteries were researched by plastic mass injection.

2. Superior thyroid artery

2.1. Introduction

The STA was studied on a total of 329 cases, 178 in the male sex and 151 in the female sex. Of the 329 cases, 167 cases were right STA and 162 cases were left STA.

2.2.1. STA origin

The origin of STA we studied on a total of 329 cases, 167 being right arteries and 162 left arteries. We found the following situation:

- In 238 cases (72.34% of the cases) the origin of STA was from the ECA, 131 cases were right arteries and 107 cases were left arteries;
- in 46 cases (13.98% of cases) the origin of the STA was from the CCA, 11 cases were right arteries and 35 cases were left;
- in 25 cases (7.60% of cases) the origin of the STA was in the terminal branch of the CCA, 13 cases were right arteries and 12 cases left arteries;
- in 18 cases (5.47% of cases), the origin of the STA was from a TLT, 11 cases being on the right and 7 cases on the left;
- in 2 cases (0.61% of all cases), one on the right side and the other on the left side had their origin from a TLF.

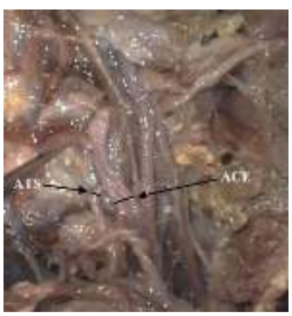


Fig. 14. Left STA originating on the medial aspect of the ECA, 10.2 mm above the terminal branch of the CCA.

Fig. 15. Left STA originating on the medial aspect of the CCA, 2.5 mm below its terminal branch.

Fig. 16. Left STA originating at the medial aspect of the CCA terminal branch.

2.2.2. STA morfometry

We determined the **diameter at the origin of the STA** in 305 cases, 153 right arteries and 152 left arteries, and found it to be between 1.2-5.4 mm.

Fig. 38. The right STA is 2.4 mm in diameter caudally and cranially its 6.0 mm.; the ECA diameter: 6.8 mm,

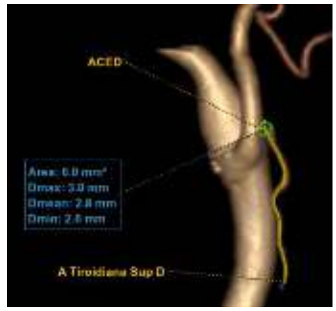


Fig. 39. The right STA originating in the ECA has a diameter at the origin of 2.8 mm (male).

Fig. 43. The left STA originating on the postero-medial flank of the CCA is 4.9 mm in diameter..

The diameter of the right STA at its origin was found to be between 1.2-5.4 mm and the **diameter of the left STA at its origin** was between 1.2-5.2 mm**.**
In cases where the **origin of the STA was at the level of the CCA**, the diameter of the STA was between 1.4-5.2 mm.

In cases where the **origin of the STA was at the level of the BCT**, the diameter of the STA was between 2.2-5.4 mm. In 5 cases (7.46% of cases) the right arteries were equal in diameter to the left arteries.

Fig. 47. The right STA originating in the BCT, diameter at origin 2.6 mm (female).

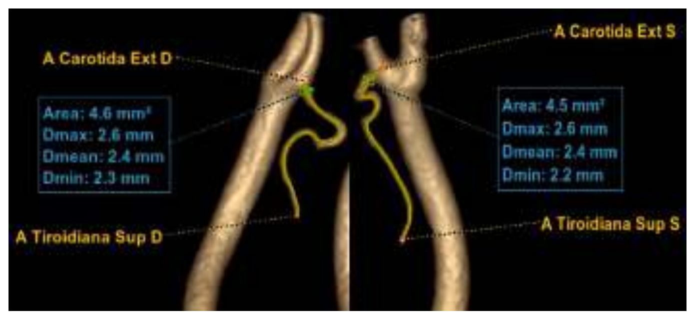


Fig. 54. The two STA, right and left, are equal in diameter: 2.4 mm (female).

The **length of the STA from its origin to its terminal branch** was found to be between 20.0-88.4 mm, right STA was 20.0-88.4 mm and the left STA was 20.7-65.0 mm.

Fig. 72. The length of the right STA originating from the ECA is 64.2 mm (male).

The STA course was described on 280 cases, 142 cases for the right arteries (50.71% of cases) and 138 cases for the left arteries (49.29% of cases). We described two portions of the STA path: *the first portion* from the origin, of short length but variable in size and direction, and *the second portion*, up to the terminal branch, which in most cases is sinuous, presenting one to seven curves with concavities oriented differently, sometimes taking the appearance of different letters, question marks, etc.

Fig. 59. The right STA is in the shape of the letter omega.

3. Inferior thyroid artery (ITA)

3.1. Introduction

The ITA was followed up on a total of 345 cases, 161 cases being in the male sex and 184 cases being in the female sex. Most cases were represented by CT angiographies, 170 cases, by dissection we researched 125 arteries, and by plastic mass injection, 50 arteries were studied.

3.2. Results

3.2.1. ITA origin

The origin of ITA was followed on 182 cases, in the male sex 90 arteries and in the female sex 92 arteries, 88 cases for the right side, and 94 cases for the left side. We found that in 72 cases it originated directly from the SA trunk, and in 110 cases the ITA originated from arterial trunks with highly variable branching.

In cases where the ITA originated directly from the SA, 38 cases were right ITAs and 34 cases were left ITAs. In cases where the ITA originated from the arterial trunks, 50 cases were right ITAs and 60 cases were left ITAs.

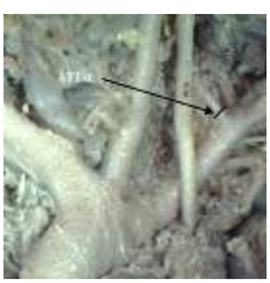


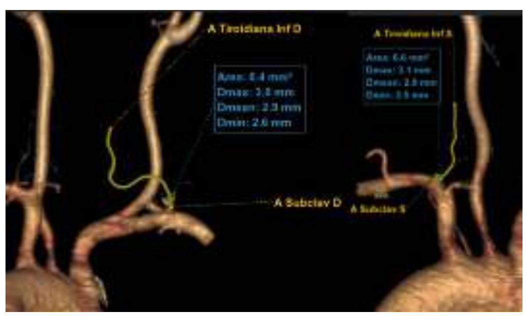
Fig. 107. Left ITA with its origin on the superior face of the SA (male).

Fig. 108. The origin of the right ITA is on the posterosuperior aspect of the SA (female).

Author	Study object	Number of cases	Total TCT %	R TCT %	L TCT %	Total SA	R SA %	L SA %
Adachi (1928)	cadaver	292	94,50	92,30	96,90	4,70	7,0	2,30
Rohlich (1940)	cadaver	192	92,50	92,80	92,0	7,0	7,20	6,80
Daseler (1959)	cadaver	770	80,25	38,48	41,69	-	9,55	6,58
Lippert (1985)	-	-	85,0	-	-	8,0	-	-
Toni (2004)	cadaver	160	94,80	94,90	94,08	5,15	5,10	5,20
Rimi (2009)	cadaver	57	-	87,0	90,20	-	13,0	9,80
Magona (2012)	cadaver	72	87,50	89,50	85,30	12,50	10,53	14,71
Bergman (2013)	cadaver	200	90,50	-	-	7,5	-	-
Roshan (2015)	cadaver	100	-	96,0	100,0	-	4	-
Takkallapalli (2015)	cadaver	108	88,72	87,20	82,80	10,90	12,35	9,75
Graves (2017)	cadaver	70	82,90	80,0	85,71	10	11,40	8,60
Esen (2018)	angio CT	640	92,40	95,0	90,30	4,8	2,8	2,0
Tsegay (2019)	cadaver	16	100	100,0	100,0	-	-	-
Personal cases (2023)	***angioCT, dissections, plastic injections***	***182***	***60,44***	***56,82***	***63,83***	***39,56***	***43,18***	***36,17***

Tabel nr. 11. The origin of ITA from TTC and directly from SA in percentages: personal results compared to data in literature

We traced the origin of the **ITA bilaterally** (right/left) on a total of 84 cases, finding that the ITA had the same origin on both sides of the body in 42 cases, in 20 cases it was directly from the SA, and in 22 cases the origin was from an arterial trunk.



R L

Fig. 113. The origin of the right ITA is directly from the posterosuperior aspect of the SA and the origin of the left ITA is directly from the anterosuperior aspect of the SA (female).

On the right side, in the male sex arteries, the distance between the origin of the SA and the origin of the ITA was between 11.0-75.0 mm, and in the left arteries, the distance was between 34.0-80.0 mm.

In the female sex, the distance between the origin of the SA and the origin of the ITA was found to be between 11.0-74.1 mm, in the right arteries the distance was found to be between 11.0-52.2 mm, and in the left arteries it was found to be between 23.0-71.2 mm.

Fig. 116. The distance between the origin of the right SA and the origin of the ITA: 75.0 mm (male).

Fig. 119. The distance between left SA origin and ITA origin: 74.1 mm (female).

3.2.2. ITA morfometry

The **ITA diameter at its origin** was measured on 178 arteries, 89 on the right side and 89 on the left side, and found to be between 1.1-4.1 mm, with the right ITAs between 1.1-3.9 mm and the left ITAs between 1.4-4.1 mm.

In the male sex, the ITAs diameter was found to be between 1.1-4.1 mm, and in the female sex, the ITAs were between 1.4-3.9 mm.

Fig. 123. The left ITA originating on the superior aspect of the SA has a diameter of 4.1 mm (male).

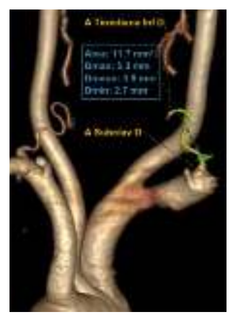
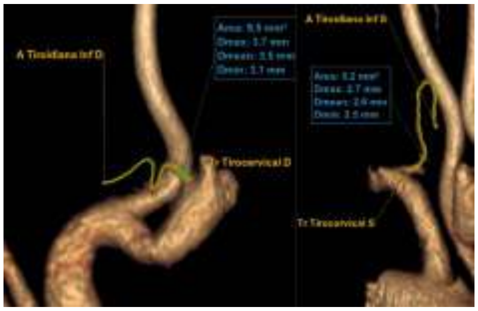


Fig. 124. The diameter of the right ITA at the origin is 3.9 mm (female).

On a total of 49 cases, we studied the ITA **diameter at the origin comparing right to left** and found that in 19 cases the right ITA was 0.1-1.1 mm larger than the left ITA; in 22 cases the left ITA was 0.1-1.1 mm larger and in 8 cases the two arteries had the same diameter.

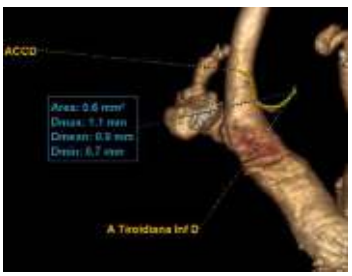


R L R L

Fig. 126. The right ITA in the TCT has a diameter of 3.5 mm and the left ITA, also originating in the TCT, has a diameter of 2.6 mm, the right diameter being 0.9 mm larger than the left (male).

Fig. 130. The two ITAs, right and left, are originally equal in diameter: 3.5 mm; the left ITA's trajectories create the appearance of the letter omega (female).

We found the **ITA diameter at its termination** to be between 0.4-2.3 mm, with the right ITAs between 0.4-2.3 mm and the left ITAs between 0.6-2.0 mm.



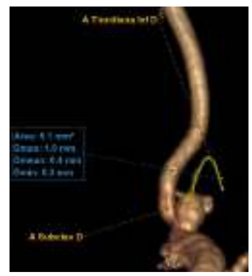
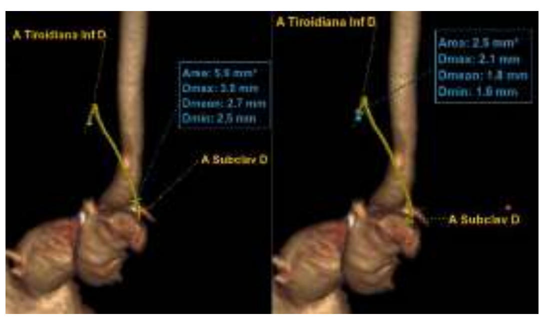


Fig. 131. The diameter of right ITA at its termination: 0.9 mm (male).

Fig. 133. The diameter of right ITA at its termination: 0.4 mm (female).

The difference between the diameter at the origin and the diameter at the termination of the ITA was found to be between 0.1-3.0 mm, between 0.1-3.0 mm in the right arteries and between 0.4-3.0 mm in the left arteries.



R L

Fig. 137. The diameter at the origin of the right ITA is 2.7 mm and the diameter at the end of the same artery is 1.8 mm, with a difference of 0.9 mm between them (male).

The **ITA length** was found to be between 16.5-77.9 mm, with right ITAs between 16.5-75.5 mm and left ITAs between 21.3-77.9 mm.

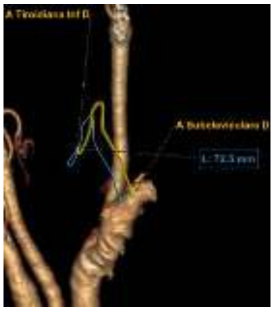
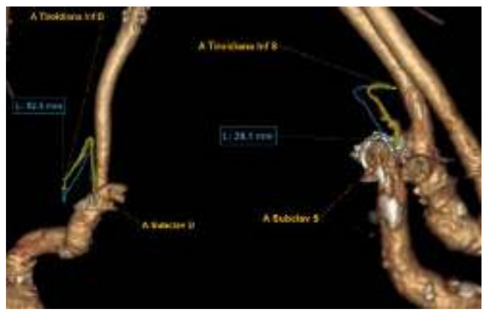


Fig. 153. The length of the right ITA is 72.5 mm (male).

Fig. 155. The length of the right ITA is 75.5 mm (female).

The right/left ITA length difference was determined on 47 cases, finding that in 26 cases the right ITA was 1.5-34.30 mm longer and in 21 cases the left ITA was 1.3-25.0 mm longer.



R L

Fig. 157. The right ITA is 52.4 mm long and the left ITA is 28.1 mm long, with a difference of 34.3 mm between them (male).

We studied the ITA course both for ITAs arising from arterial trunks and for ITAs arising directly from SA.

The arterial trunks, studied on 76 cases, showed three different orientations: vertical, supero-medial, and supero-lateral.

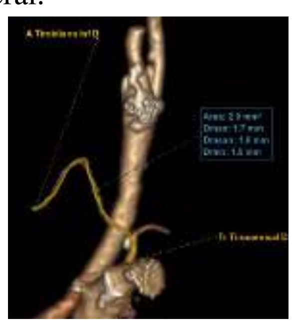


Fig. 165. The right TCT, with initial vertical trajectory (male).

Fig. 168. The left TCT, with initial vertical trajectory (female)

The number of curves described by ITAs on their path was studied on 118 cases, finding between 1 and 6 curves until branching into terminal branches.

When there are two curves located vertically they can have the appearance of an italic "S", which can be located vertically, obliquely, or have the appearance of an inverted italic "S". We have also encountered cases where the arrangement of the curves has the appearance of the letters "M" and "C".

Fig. 178. The ITA course makes the appearance of a question mark (female).

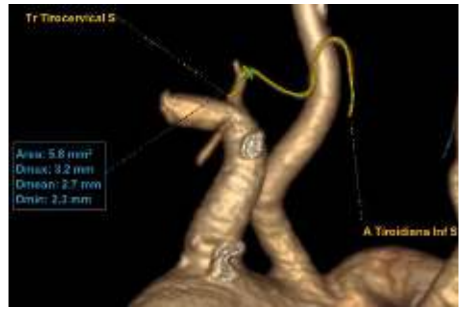


Fig. 179. The left ITA course creates the appearance of the letter "M" (female).

3.2.3. Morphometric comparison between STA and ITA

The diameters of the two arteries at their origin and at their termination were compared according to sex and the two sides of the body, right and left.

Diameter comparison at the origin of the arteries was performed on 80 cases:

- In 48 cases (60.0% of cases) we found that the diameter at the origin was larger in the STA compared to the ITA, with differences ranging from 0.1-1.6 mm;
- In 29 cases (36.25% of cases) we found that the diameter at the origin was larger in the ITA than in the STA, with differences ranging from 0.1-1.7 mm;
- In 3 cases (3.75% of cases), the two arteries were equal in diameter, this variant was found only in the male sex.

In the male sex, comparing the diameter at the origin of the corresponding STA and ITA arteries, we found that in 24 cases (57.14% of cases) the diameter was larger in the STA than in the ITA, with differences ranging from 0.1-1.6 mm, the difference between the extreme values being 1.5 mm. In ascending order of difference values, the situation was as follows:

- 0.1-0.7 mm: 20 cases (83.33% of cases);
- 1.1-1.6 mm: 4 cases (16.67% of cases).

The right STA had a diameter at the origin greater than the diameter of the corresponding right ITA in 12 cases (50.0% of cases), with differences ranging from 0.1-1.2 mm, the difference between the extreme values being 1.1 mm. In ascending order of difference values, the situation was as follows:

- 0.1-0.7 mm: 11 cases (91.67% of cases);
- 1.2 mm: 1 case (8.33% of cases).

The diameter of the left STA at the origin was larger than the diameter of the left ITA in 12 cases (50.0% of cases), with differences ranging from 0.1-1.6 mm, the difference between the extreme values being 1.5 mm.

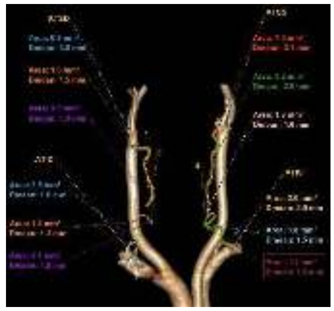


Fig. 180. The diameter of the right STA at the origin is 3.0 mm, larger than the diameter of the right ITA (1.8 mm) by 1.2 mm; the diameter of the left STA is 3.1 mm; being larger than the diameter of the left ITA (3.0 mm) by 0.1 mm; the diameter at the termination of the right STA is 1.3 mm, being larger than the diameter of the left ITA (1.2 mm) by 0.1 mm (male).

In 15 cases (35.71% of cases) we found that the diameter at the origin was larger at the ITA level than at the corresponding STA, with differences ranging from 0.1-1.7 mm, the difference between the extreme values being 1.6 mm.

The right ITAs had a larger diameter at the origin than the corresponding right STA in 10 cases (66.67% of cases), with differences ranging from 0.1-1.3 mm, the difference between the extremes being 1.2 mm.

The left ITAs had a diameter at the origin greater than the corresponding left STA diameter in 5 cases (33.33% of cases), with differences between 0.2-1.7 mm, and the difference between the extremes being 1.5 mm.

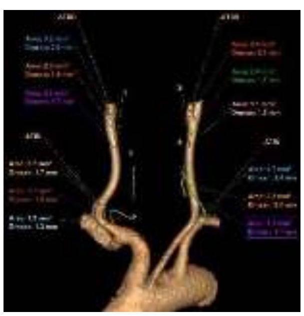


Fig. 181. The right STA has a diameter at the origin of 2.0 mm, being 0.2 mm smaller than the diameter of the right ITA; the left STA has a diameter of 2.1 mm, being 0.3 mm smaller than the diameter of the left ITA; the right STA has a diameter at its termination of 1.7 mm, being 0.4 mm larger than the terminal diameter of ITA right; The left STA has a terminal diameter of 1.2 mm, being 0.4 mm smaller than the terminal diameter of the right ITA (male).

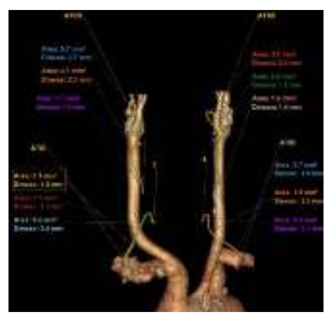


Fig. 182. The right STA has a diameter at the origin of 2.7 mm, being 1.2 mm larger than the ITA diameter; the left STA has a diameter at the origin of 2.0 mm, being 0.1 mm larger than the ITA diameter; the right STA has a terminal diameter of 1.5 mm, being 0.7 mm larger than the ITA diameter; the left STA has a terminal diameter of 1.4 mm, being 0.3 mm larger than the ITA diameter (female).

The right ITAs had a diameter at its origin greater than the diameter of the corresponding right STAs in 10 cases (71.43% of cases), with differences ranging from 0.1-1.7 mm, the difference between the extreme values being 1.6 mm.

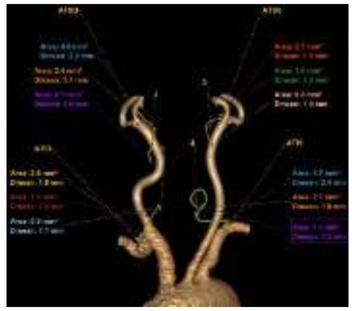


Fig. 203. The right STA has a diameter at the origin of 2.2 mm, which is 0.4 mm larger than the ITA diameter (1.8 mm); the left STA has a diameter at the origin of 1.9 mm, which is 0.5 mm smaller than the ITA diameter (2.4 mm); the terminal diameter of the left STA is 1.0 mm, which is 0.2 mm smaller than the ITA diameter (female).

The left ITA was larger in diameter at the origin than the corresponding left STA in 4 cases (28.57% of cases), with differences ranging from 0.2-0.8 mm, the difference between the extremes being 0.5 mm.

The comparison of the diameter at the termination of the arteries was carried out on 78 cases, finding the following:

- In 42 cases the diameter at termination was larger in STAs than ITAs, with differences ranging from 0.1-10.0 mm;
- In 28 cases the diameter at termination was larger at the ITA than at the corresponding STA, with differences ranging from 0.1-12.0 mm;
- In 8 cases the two arteries were equal in diameter.

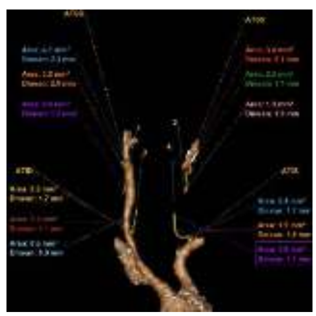


Fig. 184. The right STA has a diameter of 2.3 mm, being 0.1 mm larger than the ITA diameter (2.2 mm); the left STA has a diameter of 2.1 mm, being 0.4 mm larger than the ITA diameter (1.7 mm); the right STA has a terminal diameter of 1.7 mm, being 0.8 mm larger than the ITA diameter (male).

In 16 cases (40.0% of the cases) we found that the diameter at termination was larger at the ITA level compared to the corresponding STA, with differences ranging from 0.1-0.8 mm, the difference between the extreme values being 0.7 mm.

The right ITAs had a larger diameter at termination than the corresponding right STA in 11 cases (68.75% of cases), with differences ranging from 0.1-0.8 mm, the difference between the extreme values being 0.7 mm.

The left ITAs were larger than the corresponding left STA in 5 cases (31.25% of cases), with differences between 0.2-0.7 mm, and the difference between the extremes being 0.5 mm.

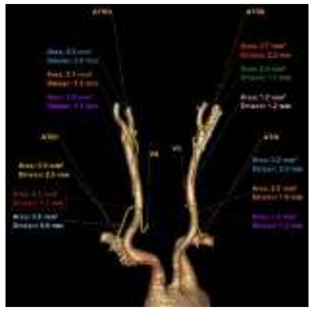


Fig. 185. The right STA has a diameter of 2.9 mm, being 0.4 mm larger than the ITA diameter (2.5 mm); the left STA has a diameter of 2.2 mm, being 0.2 mm larger than the ITA diameter (2.0 mm); the right STA has a terminal diameter of 1.1 mm, being larger than the ITA terminal diameter 0.9 mm by 0.2 mm; the terminal diameter of the left STA is equal to the terminal diameter of the left ITA, both being 1.2 mm (male).

In 5 cases (12.50% of cases), the two arteries were equal in diameter.

In the female sex, comparing the diameter at the end of the corresponding STA and ITA arteries, we found that in 23 cases (60.53% of cases) the diameter was larger in the STA than in the ITA, with differences ranging from 0.1-10.0 mm, the difference between the extreme values being 9.9 mm.

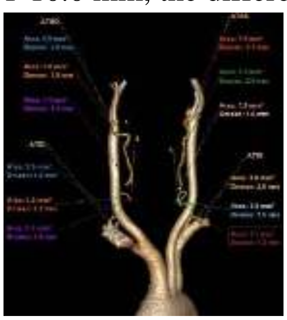


Fig. 186. The right STA has a diameter of 3.0 mm, being 1.2 mm larger than the diameter of the right ITA; the left STA has a diameter at the origin of 3.1 mm, being 1.1 mm larger than the diameter of the left ITA; terminally the right STA has a diameter of 1.5 mm, being 0.3 mm larger than the terminal diameter of the right ITA; the left STA has a terminal diameter of 2.0 mm, being 0.8 mm larger than the terminal diameter of the left ITA (female).

Fig. 187. The right STA has at its origin a diameter of 2.3 mm, being 0.2 mm smaller than the ITA diameter; the left STA has a diameter of 2.5 mm, being 0.3 mm larger than the ITA diameter; terminally the right STA has a diameter of 1.0 mm, (being 0.1 mm smaller than the ITA diameter); terminally the left STA has a diameter equal to the ITA diameter, both being 1.2 mm, (female).

4. The ima thyroid artery

4.1. Introduction

Neubauer's ima thyroid artery or middle thyroid artery (TIMA) was studied on a total of 290 cases from which 82 were obtained by dissection of formalin-fixed cadavers and 208 from CT angiographies, from these 132 cases were of male sex and 158 cases were female sex.

4.2. Results

TIMA was found in 16 cases, 10 cases in the male sex and 6 cases in the female sex. Of these, 12 cases were left TIMA (10 cases in males and 2 cases in females) and 4 cases were right TIMA, found only in the female sex.

In 15 cases, the arteries originated in the AA, 10 cases in the male sex and 5 cases in the female sex. In only one case, in the female sex, did we find the origin of the TIMA at the BCT level.

Fig. 208. The left TIMA, originating on the posterosuperior aspect of the AA, posterior to the origin of the VA, between the left CCA and the left VA, originating in the AA and measuring 5.4 mm in diameter and 52 mm in length (female).

Fig. 209. The right TIMA originates on the anterior face of the BCT, having a diameter at the origin of 2.5 mm (female).

4.2.1. The TIMA with its origin in the AA

The TIMAs originated on the postero-superior aspect of the AA in 9 cases, and in 5 cases the TIMAs originated on the superior aspect of the AA, all cases being in the male sex. Its origin is located laterally to the VA, in only one case, in the female sex, finding its origin in the AA medial to the VA, which also originated from the AA.

Author	Frequence %
Henle (1868)	6,0
Gruber (1872)	4-10,0
Adachi (1928)	0,4
Faller (1947)	1,5-12,3
Krudy (1980)	1,5
Hollinshead (1982)	0,4-12,2
Lippert (1985)	6,0
Simmonds (1987)	1,5-12,3
Bergman (1988)	12,2
Ylmaz (1993)	0,77
Kamparoudi (2016)	3,8
Esen (2018)	2,3
Natsis (2021)	<2%
Sing (2022)	3,0
Novakov (2022)	0,4-12,2
Yuraskpong (2022)	3,3
Personal cases (2023)	*5,59;* *M: 6,45; F: 4,58*

Tabelul 15. The TIMA frequency comparison between personal results with literature results.

The origin of the TIMA in the AA was located between the CCA and the SA. In 5 cases it was located midway between the left CCA and the left SA, in 8 cases the origin of the TIMA was closer to the CCA origin, and in 2 cases it was closer to the SA origin, and in the female sex the presence of the TIMA was associated with a VA originating in the AA. In 8 cases, the left TIMA existed with a left ITA.

Fig. 210. Left TIMA originating in AA, midway between left CCA and left SA; with a slightly conical dilatation at its origin; diameter at origin 2.8 mm, 0.2 mm larger than the left ITA diameter (2.6 mm); TIMA length 114 mm (male).

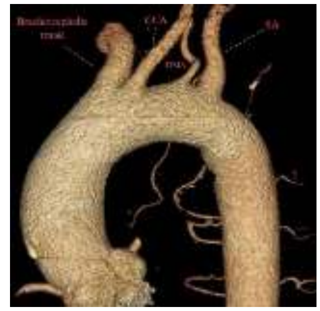


Fig. 211. The left TIMA originating on the superior aspect of the AA, closer to the origin of the left SA than to the left CCA and laterally to the left VA also originating from the AA; TIMA diameter at origin 2.3 mm (male).

4.2.2. TIMA diameter

The diameter of the left TIMA originating from AA was found to be between 2.1-4.0 mm in 11 cases (68.75% of cases), in the male sex it was between 2.1-2.9 mm in 10 cases (90.91% of cases), and in the female sex between 3.5 and 4.0 mm in 1 case each. The diameter of the right TIMA originating from AA was found to be between 2.5-2.7 mm in 4 cases in the female sex. The diameter of the left TIMA originating from BCT was 2.5 mm.

4.2.3. TIMA course

In 37.5% of cases, when its origin was in the aortic arch, it may present a slight conical dilatation with the base inferiorly, which is only found in the male sex. The course may be vertically straight in the midline, anterior to the trachea, found in both the left and right TIMA in both sexes. The vertical ascending course may show 2-3 overlapping curves, creating a wavy course. At other times, the TIMA course may be oblique supero-laterally, parallel to the CCA, passing posteriorly to the CCA and taking an ascending course towards the thyroid gland.

TIMAs are more frequently found in cadavers, 12.50% more than in angiograms, a fact also reported by Kamparoudi, who gives a difference of 1%.

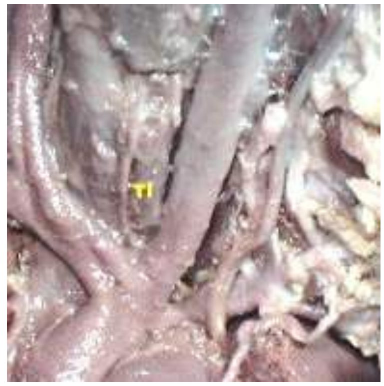


Fig. 213. The right TIMA originates on the posterosuperior aspect of the AA, closer to the left CCA than to the BCT; it has a rectilinear midline ascending course, 2.7 mm in diameter (male).

The length of the TIMA, from its origin to its terminal branching, was found to be between 5.2-142 mm, being longer in the male sex.

GENERAL CONCLUSIONS

Since the discovery of the thyroid gland, it has been extensively studied by anatomists, physiologists, pathologists, internists, and surgeons. Given its arterial supply, the thyroid arteries have been considered to be the most important in providing vascularity to the gland, and it also receives arterial branches from other arteries in the vicinity of the gland. Hollinshead states that the thyroid and adrenal glands each have the most abundant blood vasculature of all the organs in the body, in relation to their size. The major thyroid arteries (superior, inferior, and sometimes the third artery, the ima artery), are susceptible to multiple variations in origin, morphometry, course, and the collateral branches they supply, which explains the percentage differences between authors in describing their morphology.

The vasculature of the thyroid gland is mainly provided by the two arteries, STA and ITA, which we found to be present in almost all cases, except for a small number of cases, in which ITA may be missing, cases that show the existence of TIMA.

Bergman considers the STA to have a more constant morphology (especially its origin) than the ITA, Lovasova states that the ITA morphology is more variable than that of the STA.

The percentage differences (sometimes appreciable), existing in the anatomical landmarks of the thyroid arteries followed, the minimum and maximum values, are frequently represented by a single case, which makes these differences somewhat artificial, considering that it would be more correct to consider the average of these values. For this reason, I have presented in the discussion chapter the highest frequency of the features found by eliminating their extreme values.

Right/left asymmetries and sex-related asymmetries are also very common with regard to the origin of the thyroid arteries, with Magoma considering that more than 25% of the STA and 11% of the ITA show origin variants.

[Lovasova, Graves, Gupta, Paturet] argue that the main vascularization of the thyroid gland and the neck in general is provided by the ITA. Other authors consider that the STA provides most of the vascularisation of the thyroid gland [Gursharan, Mariolis, Esen, Dessie, Ozgur, Roshan, Poutoglidis].

My opinion, based on the findings of this study, is that, in general, the importance of both thyroid arteries should be taken into account, as the existence of the ITA increases the volume of blood reaching the gland. The dominance of one artery or the other varies from subject to subject, depending on the arterial diameter at origin and at termination. Thus, depending on the diameter at the origin of the thyroid arteries, the STAs are more voluminous 6.15% of the time than the ITAs, with the right STAs being 4.15% more voluminous than the left arteries. In the male sex, STA is larger in diameter in 15.37% of cases and in the female sex in 26.33% of cases.

ITAs are larger than STA more frequently in right arteries with 37.94% of cases compared to left arteries. In the male sex, the ITA is larger in diameter in 33.34% of cases, and in the female sex, in 42.86% of cases.

According to the diameter at the termination of the thyroid arteries, the diameter of the STA is 22.45% more frequently larger than the diameter of the ITA, in the male sex the diameter of the STA is larger in the right arteries in 4.26% of cases and in the female sex in 4.34% of cases.

Equality of diameter at the origin of STA and ITA was found only in the male sex in 12.50% of cases, which represents 7.15% of all cases.

Knowledge of the detailed anatomy of the thyroid arteries is crucial for optimal patient management during surgery in the neck region in general and especially in the thyroid gland. Identifying unusual thyroid artery variations preoperatively can result in minimizing any potential complications.

THESIS ORIGINALITY

First of all, it is worth mentioning the large number of personal cases on which the study on the morphology of the thyroid arteries was conducted, 674 cases, which represents one of the largest studies on this subject in the literature. This allowed me to make a comparison of the anatomical landmarks followed on the thyroid arteries with those already described in the literature that I had the opportunity to consult and that could be taken as a term of comparison, being already cited by different authors.

The use of a variety of methods: dissection, intravascular injections of plastic mass, and study of CT angiograms, an aspect also rarely found in most authors, who obtained their results using only one of the methods I used or at most two of these methods, usually dissection and imaging study.

The results obtained in my study are presented according to the sex of the subjects and right/left comparison, aspects rarely found in the literature or even not mentioned by most of the authors consulted. Establishing the morphological characteristics of the thyroid arteries separately from the characteristics of the arterial trunks from which they originated and the relationships, especially morphometric, that existed between the two arteries.

These results are supported by tables, graphs, and especially by a large number of conclusive images, which confirm the large number of cases that have been worked on.

The presentation of vascular variants in relation to the origin of these arteries, their course and morphometry (diameter and length), the presence of which is mentioned in percentages are exemplified by images that do not cast any suspicion on those mentioned.

I described a small conical formation at the level of the origin of the ITA with its origin in the SA, an aspect that we did not find reported in the literature consulted.

The different shapes the arteries have in their path from the origin to the terminal branch are represented by italic S (reported in the literature), question marks, letters V, omega, M, Z, are aspects that I did not find reported in the literature.

Also, a new aspect is the number of curves described by STA and ITA from their origin to their terminal branching.

A comparison of morphological characteristics between thyroid arteries has not been established in the literature consulted.

An explanation of the different causes that could lead to the presence of percentage differences between the personal results and the results of other authors, the original one being the time period in which the study was performed.

Consultation of a rich and varied bibliography, from the second half of the 19th century to the present day, including articles published in 2023.

The exploitation of the results presented in this study through scientific communications at national and international events, as well as the publication in extenso of articles in Romanian journals and two papers in ISI cataloged journals and one in a PubMed index journal. This demonstrates the scientific interest aroused by the topics discussed.

SELECTIVE BIBLIOGRAPHY

1. Adachi B Das Arteriensystem Der Japaner. Volume II Maruzen; Kyoto, Japan: 1928.
2. Adachi B. The arterial system of Japanese. Vol. 1. Kyoto: Kenkyusha, 1929, 58 62
3. Adomnicăi Gh, Chiriac M, Antohe D, Zamfir M - Arteria subclavia sinistra. In: Anatomia trunchiului. Vol I. Toracele. Litografia I.M.F. Iaşi, 1978, 251-254
4. Albu I, Georgia R Anatomie topografică. Ed. ALL, Bucureşti, 1998, 63-66; 73-75,
5. Anagnostopoulou S, Mavridis I. Emerging patterns of the human superior thyroid artery and review of its clinical anatomy. Surg Radiol Anat. 2014;36:33–38
6. Anita T, Dombe D, Asha K, Kalbande S. Clinically relevant variations of superior thyroid artery: an anatomic guide for neck surgeries. Int J Pharm Biomed Sci, 2011; 2(2): 51 -54
7. Banneheka S, Chiba S, Fukazawa M, Tokita K, Arakawa T, Suzuki R, Miyawaki M, Kumaki K (2010) Middle thymothyroid artery arising from the common carotid artery: case report of a rare variation. Anat Sci Int 85(4):241–244. https://doi.org/10.1007/ s12565-009-0055-9
8. Bergman RA, Thompson SA, Afifi AK, Saadeh FA Compendium of human anatomic variation. Baltimore, Urban & Schwarzenberg, 1988.
9. Bordei P, Iliescu DM , Rusali LM, Hainarosie R, Jecan RC, Popa CC Resin based materials used to observing the variations of the origin of the superior thyroid artery with importance in cervical and cranial pathology. Mater Plast, 2019, 56 (1): 115-119
10. Bouchet A., Cuilleret J. Le cou, le thorax. In: Anatomie topographique, descriptive et fonctionnelle. Vol.2. Ed.Simep, Paris, 1991, 707-722; 773; 798-805
11. Branca JJV, Lascialfari Bruschi A, Pilia AM, Carrino D, Guarnieri G, Gulisano M, Pacini A, Paternostro F The Thyroid Gland: A Revision Study on Its Vascularization and Surgical Implications. Medicina 2022, 58: 137-141

12. Cappabianca S, Scuotto A, Iaselli F, Pignatelli di Spinazzola N, Urraro F, Sarti G Computed tomography and magnetic resonance angiography in the evaluation of aberrant origin of the external carotid artery branches. Surg Radiol Anat, 2012, 34(5): 393-399
13. Chandra PHV Relation of external branch of superior laryngeal nerve to superior thyroid artery and cernea classification. Int J Sci Res, 2017, 6 (4): 797-798
14. Chandrakala SP, Mamatha Y, Thejaswini KO. Variations in the origin of inferior thyroid artery and relation of the artery with recurrent laryngeal nerve. Natl J Clin Anat. 2013, 2: 11–15.
15. Chiriac M, Zamfir M, Antohe D - Artera subclaviculară. In: Anatomia trunchiului. Vol I, Iaşi, 1991, 251-253
16. Cigali BS, Ulucam E, Bozer C Accessory inferior thyroid artery and internal thoracic artery originating from the thyrocervical trunk. Anat Sci Int, 2008, 83: 283–285
17. Clochard RL Artères des arcs aortiques. In: Atlas d'embriologie humaine de Netter. Ed. Masson, Paris, 2002, 88-89
18. Daseler E, Anson B Surgical Anatomy of Subclavian Artery and its branches. Surg Gynecol Obstet, 1959, 108: 149-174
19. Dessie MA Variations of the origin of superior thyroid artery and its relationship with the external branch of superior laryngeal nerve. PLOS ONE Digital Health 2018, 13(5):
20. Dhindsa GS, Sodhi S Variation in the origin of superior thyroid artery. J Evol Med. Dent Sci, 2014, 3, 5969–5972
21. Diaconescu N, Rottenberg N, Niculescu V Artera subclaviculară. In: Anatomia capului şi gâtului. Fascicolul II, Lito I.M.T., 1989, 1-32
22. Esen K, Ozgur A, Balci Y, Tok S, Kara E. Variations in the origins of the thyroid arteries on CT angiography. Jpn J Radiol, 2018; 36(2): 96-102
23. Faller A, Scher O. Uber die Variabilit~it der Arteriae thyroideae. Acta Anat, 1947-1948, 4 : 119-122
24. Farisse J, Argéne M, Di Marino V, Brunet C La glande thyroïde-Les glandes parathyroïdes-Le thymus. In: Chevrel JP, Fontaine C: Anatomie Clinique. Tête et cou. Ed. Springer-Verlag, Paris, 370-395, 1996
25. Fontaine C, Drizenko A - L'artère thyroïdiène supérieure. In: JP Chevrel, C Fontaine: Anatomie Clinique. Tête et cou. Ed. Springer-Verlag, Paris, 1996, 404
26. Frasin Gh, Cozma N, Chiriac V Artera titoidiană superioară.. In :Anatomia capului şi a gîtului, Litogr. I.M.F. Iaşi, 1981, 177-179, 214-223
27. Fujimoto Y, Suwa F, Kimura K (1974) A case of the left superior thyroid artery arising from the left common carotid artery and the A. thyroidea ima. Okajimas Folia Anat Jpn, 1974, 51(5):219–230. https://doi.org/10.2535/ofaj1936.51.5_219
28. Gavrilidou P, Iliescu D, Baz R, Rusali L, Bordei P Anatomical peculiarities of the origin and traject of the superior thyroid artery. ARS Medica Tomitana, 2013, 19 (3): 124-129
29. González-Castillo A, Rojas S, Ortega M, Rodríguez-Baeza A Variations in vascular anatomy and unilateral adrenal agenesis in a female cadaver with situs inversus totalis. Surg Radiol Anat, 2018, 40: 1169–1172
30. Graves JM, Henry BM, Sanna B, Pękala AP, Taterra D, Witczak K, Kucharska E, Barczynski M, Walocha AJ, Tomaszewski AK Anatomical variations of the inferior thyroid artery: a cadaveric examination. Przegląd Lekarski, 2018, 74: 12-15
31. Gruber W Jber die Arteria thyroidea ima. Virchow's Archiv, Abteilung A 1872, 54: 445-484
32. Gupta PB, Bhalla AS, Thulkar AS, Kumar S,.Mohanti A, Thakar BK, Sharma A Variations in superior thyroid artery: A selective angiographic study. Indian J Radiol Imaging 2014, 24, 66–71
33. Gursharan SD, Shubhpreet S Variation on the Origin of Superior Thyroid Artery. J Evol Med Dent Scient, 2014, 3(22): 5969-5972
34. Hayashi N, Hori E, Ohtani Y, Ohtani O, Kuwayama N, Endo S. Surgical anatomy of the cervical carotid artery for carotid endarterectomy. Neurol Med Chir (Tokyo). 2000, 45: 25–29
35. Henle J Handbuch der Gefiglehre des Menschen. Vieweg, Braunschweig, 1868, 247- 256
36. Hirose K Uber die A. thyreoidea ima Jap J Clin Exp Med 1931; 8: 486-491.
37. Hollinshead WH Head and Neck In: Anatomy for surgeons vol. 1. 1st edn. Hober and Harper, Newyork, 1962, 520-533
38. Issing, P.R.; Kempf, H.-G.; Lenarz, T. Mitteilung einer klinisch relevanten Variation der Arteria thyroidea superior. Laryngo-RhinoOtologie 1994, 73, 536–537

39. Jadhav S D, Ambali M P, Patil R J, Roy P P Thyrolingual trunk arising from the common carotid bifurcation. Singapore Med J, 2011, 52(12): e265-e266
40. Joshi A, S. Gupta, V. Vaniya Anatomical variation in the origin of superior thyroid artery and it's relation with external laryngeal nerve. Natl J Med Res, 2014, 4 (02): 138-141
41. Joshi A, Vaniya V H, Shital G Patel Anatomical variation in the origin of inferior thyroid artery and relation with recurrent laryngeal nerve. Int J Res Med, 2014, 3(3): 137-141 e
42. Kamina P Artères de la tête et cou. In: Tête et cou. Muscles, Vaisseux, Nerfs, Viscères. Tome 1. Ed. Maloine, Paris, 1996, 64-70; 78-86
43. Kamparoudi P, Paliouras D, Gogakos AS et al. Percutaneous tracheostomy-beware of the thyroidea-ima artery. Ann Transl Med. 2016; 4(22): 449.
44. Krudy AG, Doppman JL, Brennan MF. The significance of the thyroidea ima artery in arteriographic localization of parathyroid adenomas. Radiology. 1980; 136(1): 51-45
45. Langman J, Sadler T-WW Dévellopement des vaisseaux. Artères. In: Embryologie médicale, Ed. Pradel, Paris, 1995, 227-234
46. Lemaire V, Jacquemin G; Medot M, Fissette J. Thyrolingual trunk arising from the common carotid artery: A case report. Surg. Radiol. Anat. 2001, 23, 135–137
47. Lippert H, Pabst R Arterial Variations in Man. Classification and Frecvency. Ed. J.F.Bergmann Verlag, Munchen, 1985, 4-9; 78-85
48. Lo A, Oehley M, Bartlett A, Adams D, Blyth P, Al-Ali S Anatomical variations of the common carotid artery bifurcation. ANZ J Surg, 2006, 76 (11): 970-972
49. Lovasova K, Kachlik D, Santa M, Kluchova D Unilateral occurrence of five different thyroid arteries-a need of terminological systematization: a case report. Surg Radiol Anat, 2017, 39: 925–929
50. Lucev N; Bobinac D, Maric I; Dreš´cik I Variations of the great arteries in the carotid triangle. Otolaryngol. Head Neck Surg. 2000, 122, 590–591
51. Mada S, Hisatomi K, Kawahara K, Matsuo T Uber die A. thyreoidea ima des Japaners in Kyushu. J Kurume Med Assoc 1955; 18:1128- 1132.
52. Magoma G, Saidi H, Kaisha WO Origin of thyroid arteries in a Kenyan population. An Afric Surg, 2012, 9: 50-54
53. Mariolis-Sapsakos T, Kalles V, Papapanagiotou I, Bonatsos V, Orfanos N, Kaklamanos IG, et al. Bilateral aberrant origin of the inferior thyroid artery from the common carotid artery. Surg Radiol Anat. 2014;36:295–297.
54. Mata RJ, Mata RF, Souza CRM, Nishijo H, Ferreira AT Arrangement and prevalence of branches in the external carotid artery in humans. Ital J Anat Embryol, 2012;117(2): 65-74
55. Mehta, V.; Suri, R.K.; Arora, J.; Rath, G.; Das, S. Anomalous superior thyroid artery. Kathmandu Univ. Med. J. 2012, 8, 429–431
56. Moore LK, Dalley FA Glande thyroide. In: Anatomie Médicale. Aspects fondamentaux et applications cliniques. Ed. De Boeck Université, Bruxelles, 2001, 1030-1035,
57. Moriggl B, Storm W Absence of three regular thyroid arteries replaced by an unusual lowest thyroid artery (A. thyroidea ima): a case report. Surg Radiol Anat, 1996, 18: 147-150
58. Natsis IK,·Tsitouridis IA, Didagelos VM, Fillipidis AA, Vlasis GK, Tsikaras DP Anatomical variations in the branches of the human aortic arch in 633 angiographies: clinical significance and literature review. Surg Radiol Anat, 2009, 31: 319-323
59. Natsis K, Raikos A, Foundos I, Noussios G, Lazaridis N, Njau SN. Superior thyroid artery origin in Caucasian Greeks: a new classification proposal and review of the literature. Clin Anat. 2011;24:699–705
60. Netter F Atlas de anatomie a omului.Ed. Callisto Bucureşti, 2012, planşa 76
61. Ngo Nyeki A-R, Peloni G, Karenovics W, Triponez F, Sadowski SM Aberrant origin of the inferior thyroid artery from the common carotid artery: a rare anatomical variation. Gland Surgery, 2016, 5(6): 644-646
62. Nochikattil, S.K. Thyrolingual trunk arising from common carotid artery- A case report. J. Clin. Diagn. Res. 2017, 11, AD01–AD02
63. Novakov SS, Delchev SD Two cases of variations in inferior thyroid arterial pattern and their clinical implications. Folia Morphol (Warsz). 2022, https://doi.org/10.5603/FM.a2022.0032.10. 5603/FM.a2022.0032

64. Núñez MH, Menchaca-GutiérrezJL, Pinales-Razo R, Elizondo-Riojas G, Quiroga-Garza A, Fernandez-Rodarte BA, Elizondo-Omaña RE, Guzmán-López S Origin variations of the superior thyroid, lingual, and facial arteries: a computed tomography angiography study Surg Radiol Anat, 2020, 42(9): 1085-1093
65. Nyeki A.-R.N., Peloni G., Karenovics W., Triponez F., Sadowski S.M. Aberrant origin of the inferior thyroid artery from the common carotid artery: A rare anatomical variation. Gland Surg, 2016, 5: 644–646
66. Ongeti KW; Ogeng'O JA Variant origin of the superior thyroid artery in a Kenyan population. Clin. Anat. 2011, 25, 198–202
67. Ozgur Z, Govsa F, Ozgur T Assessment of origin characteristics of the front branches of the external carotid artery. J Craniofacial Surg, 2008, 19: 1159–1166
68. Ozgur Z, Govsa F, Celik S, Ozgur T Clinically relevant variations of the superior thyroid artery: An anatomic guide for surgical neck dissection. Surg. Radiol. Anat. 2009, 31: 151–159.
69. Panaitescu V., Gănuţă N., Roşu M. Anatomia regională a feţei şi gâtului. Ed. Medicală Naţională, Bucureşti, 2002, 219-230
70. Papilian V Glanada tiroidă. In : Anatomia omului. Vol. 2, Splnhnologia, Ed. Bic All, Bucureşti, 1998, 388-392.
71. Patel JP, Dave RV, Shah RK, Kanani SD, Nirvan AB A study of superior thyroid artery in 50 cadavers. Int JBiol Med Res, 2013, 4: 2875-2878
72. Paturet G Traité d'anatomie humaine, Tome III, Ed. Masson, Paris, 1958, 195-219, 243-258, 271-276, 363-427.
73. Poisel VS, Golth D (1974) Zur Variabilita¨t der großen Arterien im Trigonum caroticum. Wien Med Wochenschr 124(15):229–232
74. Poutoglidis A, Stavros Savvakis S, Karamitsou P, Forozidou E, Paraskevas G, Lazaridis N, Fyrmpas G, Karamitsou A, Skalias A Is the origin of the superior thyroid artery consistent? A systematic review of 5488 specimens. Am J Otolaryng, 2023, 44 (2):
75. Putz R, Pabst R Sobotta. Muscles, vaisseux et nerfs du cou. In: Atlas d'Anatomie Humaine. Tome 1. Tête, cou, membre supérieur. Ed. Méd Int, Paris, 1994, 137-156
76. Ranga V, Abagiu N, Panaitescu V, Papahagi P, Iapas Al Artera tiroidiană inferioară. In: Anatomia omului. Capul şi gâtul. Ed Cerma, Bucureşti, 1995, 65-73; 209,
77. Rimi KR, Ara S, Hossain M , Shefyetullah KM, Naushaba H , Bose BK Postmortem Study of Thyroid Arteries in Bangladeshi People, L Anat Bangladesh, 2009, 7 (1): 26-33
78. Roshan S, Pandey N, Bhivate V, Kharate RP Morphometric study of inferior thyroid artery in cadavers. Int J Anat Res, 2015, 3: 1726–1731
79. Rouvière H, Delmas A. Anatomie humaine.Descriptive, topographique et fonctionnelle. Tome 1. Tête et cou. Ed. Masson, Paris, 1997, 199-202; 215-224
80. Sanjeev, I.K.; Anita, H.; Ashwini, M.; Mahesh, U.; Rairam, G.B. Branching pattern of external carotid artery in human cadavers. J. Clin. Diagn. Res. 2010, 4, 3128–3133
81. Sannomiya T, Yamaki K, Doi Y., Aida K. Tanaka H., Hyakutake Y., Yoshizuka M. A rare case of the double thyroid ima artery, The Kurume Medical Journal, 1996, 43: 177-180
82. Shankar VV, Komala N, Shetty S A cross-sectional study of superior thyroid artery in human cadavers. Int J Anat Res, 2017, 5(4.3): 4751–4755
83. Shivaleela C, Anupama D, Lakshmi Prabha Subhash R. Study of anatomical variations in the origin of superior thyroid artery. Int J Anat Res. 2016;4(1):1765-1768
84. Shlugman D, Satya-Krishna R, Loh L Acute fatal haemorrhage during percutaneous dilatational tracheostomy. Br J Anaesth. 2003; 90(4): 517-20
85. Singh R Study of Thyroidea Ima Artery: Narrative Review of Its Prevalence and Clinical Significanc. Basic Sciences of Medicine, 2022, 11(1): 1-4
86. Smith S.D., Benton R.S. A rare origin of the superior thyroid artery. Cells Tissues Organs. 1978;101: 91–93
87. Standring S. Gray's Anatomical. The Anatomical Basis of Clinical Practice. Ed. Elsevier-Churchill Livingstone, Edinburg.New York.Exford, 2005, 543-545; 547-563
88. Takkallapalli Anitha et al. Clinically Relevant Variations of the thyroid arteries. Journal of Chalmeda Anand Rao Institute of Medical Science 2015, 5(1):

89. Terayama N, Sanada J, Matsui O, Kobayashi S, Kawashima H, Yamashiro M Feeding artery of laryngeal and hypopharyngeal cancers: role of the superior thyroid artery in superselective intraarterial chemotherapy. Cardiovasc Intervent Radiol, 2006, 29(4): 536-543
90. Terminologia Anatomica. International Anatomical Terminology. Federative Committee on Anatomical Terminology. Ed. Thieme, Stuttgart, Germany, 1998, 79-80; 84-85
91. Testut L. - Artère thyroïdienne supérieure. In: Traité d'Anatomie humaine. Angiologie.Chapitre II. Ed. Gaston Doin, Paris, 1923, 541-542
92. Testut L.– Traité d'anatomie humaine. Angéiologie, livre IV, Ed.Gaston Doin, Paris, 1921, 127-144.
93. Testut L. Traité d'Anatomie humaine. Tome deuxième. Angéiologie. Ed. Gaston Doin, Paris, 1924, 127-129, 158-159, 569-583
94. Toh H, Kodama J, Ohomori T The anatomical consideration of the thyroidea ima artery. J Fukuoka Dent Coil 1992a; 18:448-451
95. Toh H, Tsuno K, Iha Y, and Ohomori T A rare case of double thyroid ima artery. J Fukuoka Dent Coil 1992b; 19:33-36
96. Toni R, Casa D, Castorina S, Roti E, Cedad G, Valenti G. A Meta-Analysis Of Inferior Thyroid artery Variations In Different Human Ethnic Groups And Their Clinical Implications. Ann Anat 2005; 187: 371-385
97. Toni R, Della Casa C, Castorina S, Malaguti A, Mosca S, Roti E, Valenti G. A Meta-analysis of superior thyroid artery variations in different human groups and their clinical implications. Ann Anat Anat Anz, 2004, 186: 255–262
98. Totlis T, Natsis K, Achlatis V, Pettas T, Piagkou M Thyroidea ima artery multiple branching pattern over the trachea Surg Radiol Anat, 2023, 45: 813–817
99. TsegayTA, Berhe T, Amdeslase F, Hayelom H Variations on arterial supply of thyroid gland and its clinical significance in selected universities of North Ethiopia. Int J Anat Res, 2019, 7(3.2): 6830-6834
100. Vazquez T, Cobiella R, Maranillo E, Valderrama FJ, McHanwell S, Parkin I, Sañudo JR Anatomical variations of the superior thyroid and superior laryngeal arteries. Head Neck, 2009, 31, 1078–1085
101. Wolpert SM The thyroidea ima artery: an unusual collateral vessel. Radiology, 1969; 92(2): 333-334
102. Won HS, Han SH, Oh CS, Chung IH Superior and middle thyroid arteries arising from the common carotid artery. Surg Radiol Anat 2011, 33Ş 645–647
103. Yilmaz E, Celik HH, Durgun B, Atasever A, Ilgi S Arteria thyroidea ima arising from the brachiocephalic trunk with bilateral absence of inferior thyroid arteries: a case report. Surg. Radiol Anat, 1993, 15: 197-199
104. Yurasakpong L, Nantasenamat C, Janta S, Eiamratchane P, Coey J, Chaiyamoon A, Kruepunga N, Senarai T, Langer MF, Meemon K, Suwannakhan A The decreasing prevalence of the thyroid ima artery: a systematic review and machine learning assisted meta-analysis. Ann Anat, 2022, 239: 151-158
105. Zümre, Ö.; Salbacak, A.; Çiçekciba¸si, A.E.; Tuncer, I.; Seker, M. Investigation of the bifurcation level of the common carotid artery and variations of the branches of the external carotid artery in human fetuses. Ann. Anat. Anat. Anz. 2005, 187, 361–369