"OVIDIUS" UNIVERSITY OF CONSTANŢA
FACULTY OF MEDICINE
DEPARTMENT OF PRECLINICAL DISCIPLINES

MORPHOLOGICAL CONSIDERATIONS ON THE EXTERNAL CAROTID ARTERY

DOCTORAL THESIS
ABSTRACT

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Constanţa
2013

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INTRODUCTION

Cardiology is one of the medical areas in which progress is impressive, reaching remarkable efficaciousness whose evidence is undisputed, as the cardiovascular disease mortality rate is constantly decreasing. Before becoming an autonomous field of study, it had undergone a lengthy gestation, as the current high level of excellence is the result of many efforts. As Étienne May said, "These developments are the result of a long journey with failures and errors, with indecisive battles, but also with glorious victories". It is indeed surprising to notice that the circulation mechanisms, which are vital for survival, could not be explained until after centuries of errors and conceptions which proved to be fanciful and completely irrational. For centuries, obscure and fanciful theories, as well as arguments stemming from fertile imagination, prevailed over the rigorous facts proven by way of observation and experience.

The right and left common carotid arteries are the main arteries of the neck, the scalp, the face and the anterior region of the brain. The term “carotid” derives from the Greek word “***Karotis***” (sleep), as the Greeks noticed as early as in antiquity that compression of these arteries caused profound sleep or unconsciousness. Hippocratic medicine also implies that pathological obstructions of the carotids could account for consciousness-related disorders. The right and left external carotid arteries vascularize the anterior areas of the neck, face and scalp, being involved, together with the common carotids, in the rich cervical pathology. The carotid arterial system in general and the carotid bifurcation in particular have a great clinical importance granted by facilitating access in intravascular interventions. Pathologically, the carotid bifurcation is the most common site of atheroma plaque buildup.

Given their clinical importance, the details of the carotid system and its branches have been a topic of great interest to numerous scientific research projects.

With regard to the cervical area of large vessels, stenosing lesions are frequently multiple and affect several blood vessels. A severe stenosis of a thick vessel raises the question of the existence of other stenoses of various degrees in other vessels. Therefore, it is

considered that if there is a stenosis higher than 75% at the level of the carotid sinus, the chances are 3/10 that the other carotid is the site of another characteristic stenosis, while there is only 1/10 chance that the other carotid is not affected by a prominent lesion. It has been determined that there is a straightforward connection between the stenosis of cervical vessels and the atherosclerosis of intracranial vessels. Bauer's research on 1207 patients with cerebral ischemic manifestations indicated that more than 30% of them evinced cerebral ischemic manifestations. Only 8% of the cases manifested a tight stenosis of the artery without any other traceable arteriographic lesions of other cerebral vessels. In 8% of the cases there was a stenosis on the internal carotids without any other traceable disorder. The other cases (approximately 80%) showed various associations of occlusive intracranial lesions with extracranial ones.

All the above mentioned are just a few of the reasons for which I have chosen the morphology of the external carotid artery as the subject of my PhD thesis. A further reason is the variety of anatomic forms taken by this vascular system, which leads to new additions piling up on the already numerous existing ones.

Within the general section of the present work, the introduction is followed by a chapter entitled "Current State of Scientific Knowledge", which is meant to present the morphology of the external carotid artery based on the information provided both by well-known international treaties (Testut, Rouviére, Paturet, Gray, Chevrel, Bouchet, Kamina) and by volumes published in Romania (Diaconescu, Frasin, Ranga, Niculescu, Panaitescu etc). The thesis correlates not only the above mentioned readings, but also aspects presented in various articles published by specialized journals or in atlases edited by authors highly appreciated in the scientific world. The data presented was concerned with the origin of the arteries, their course and their morphometry, as well as with collateral and terminal branches, the focus being on the variations they evince (in terms of number, size, origin, relations).

The personal contribution section opens with the working material and methods. The results are based on the analysis of more than 200 cases, using three working methods: dissection of items preserved in formalin, injection of plastic mass followed by dissection or corrosion, and analysis of CT angiograms, which are the most accurate in morphometry assessment. Selective bibliography is

added at the end of each chapter, preserving the order in which the works are cited in the text.

The outcome is presented next, being exemplified by means of personal images which are very clear, casting no doubt upon their interpretation. Each displayed aspect is accompanied by discussions, highlighting the resemblances and especially the differences and idiosyncrasies established by comparison with the data in the researched literature.

The conclusive chapter insists upon the original findings of the present research, showing their importance for morphology and especially for medical practice. The general bibliography placed at the end of the thesis enumerates the publications in alphabetical order.

The significance of the chosen topic was also emphasized by the publication of some specialty papers in which I made available the results I had obtained. I mention here the two articles published in “Ars medica tomitana”, which is a BDI-indexed review.

I wish to acknowledge the help of the academic staff of the Faculty of Medicine of “Ovidius” University in Constanţa, especially the ones in the Anatomy Department (Univ. Reader PhD Iliescu Dan and Univ. Assistant PhD Ionescu Constantin), who helped me with some of the resources necessary for running this project, namely the anatomic parts dissected or injected with plastic mass. I am particularly grateful for the assistance given by Univ. Reader PhD Baz Radu, and Doctor Bărdaş Mariana, who provided me with the CT angiograms done in the radiology departments they are running. I would also like to extend my special thanks to the members of the Assessment Committees throughout the development stages of the dissertation as well as the readers in the Examining Committee appointed for the defense of my thesis.

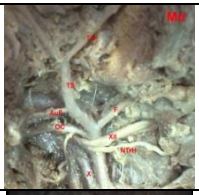
Finally, special thanks should be given to Prof. Dr. Bordei Petru, my research project supervisor, for his valuable and constructive suggestions during the four years of planning and development of this research work, which helped me to accomplish it.

PERSONAL CONTRIBUTION SECTION

WORKING MATERIAL AND METHODS

My research into the morphological characteristics of the external carotid artery was performed on a number of 206 cases, 82 cases being represented by dissections, 28 cases involving plastic mass injections followed by dissection or corrosion, and 96 CT angiograms, which allowed us to obtain results comparable and competitive with the existing data in the specialty literature.

TABLE 1 – WORKING METHODS EMPLOYED IN THE STUDY OF EXTERNAL CAROTID ARTERY.

NR.	METHOD	NUMBER OF CASES	PHOTO
1.	Dissection	82	
2.	Injection with plastic mass	28	
3.	CT Angiogram	96	
	Total	206	

MORFOLOGICAL CONSIDERATIONS ON THE ORIGIN OF THE EXTERNAL CAROTID ARTERY

The study was carried out on a number of 80 cases, represented by human corpses and CT angiograms, performed by a GE LightSpeed VCT64 Slice CT scanner. The working method used on corpses was dissection and injection with plastic mass (technovit 7143). The study was concerned with the anatomic characteristics of the origin of the external carotid artery, as well as with the size and course of the external carotid artery. The researched aspects resulted from a certain number of cases, the details under scrutiny being described in comparison with the common carotid arteries, the right and left ones respectively.

RESULTS

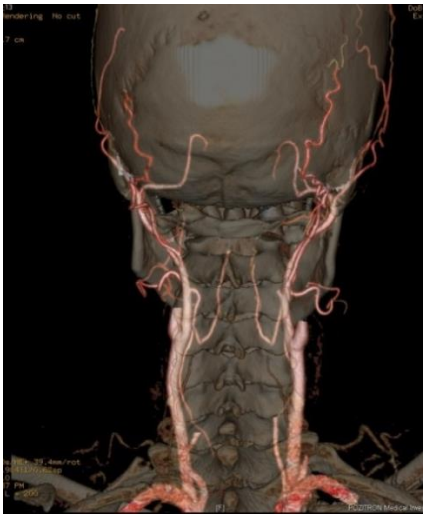


Fig. 17 - Terminal branching of the right common carotid occurs at the level of inferior C4 vertebra, and of the left one at the level of superior C4 vertebra.

The level of the external carotid artery origin in relation to the vertebral column was studied on a number of 44 cases. The

findings indicate that the branching most frequently occurred at the level of the C4 vertebral body, variant seen in 35 cases (79,55% of the cases), while in the remaining 9 cases (20,45% of the cases) the bifurcation occurred at the level of the C5 vertebral body.

Fig. 18 - Terminal bifurcation of the two common carotids situated at the same level, the right bifurcation being in wide "V" shape, while the left one has a rounded tight "V" shape. The size of the right common carotid is bigger than the size of the left one, and the internal carotids are larger in volume than the external carotids, both at and above their origin.

38 cases allowed me to trace the level of the common carotid bifurcation on the two sides of the cervical region. In 14 cases (36.84% of the cases) the terminal bifurcations of the two common carotids were on the same level, in 16 cases (42.11% of the cases) the left common carotid branched higher than the right one, while in 8 cases (21.05% of the cases) the right common carotid branched higher than the left one.

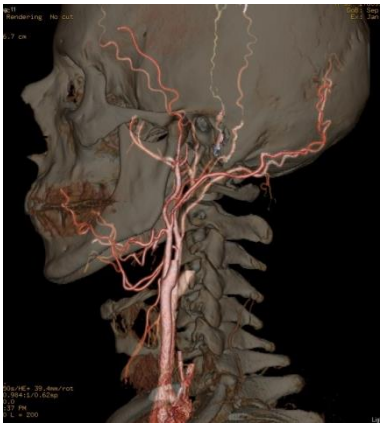


Fig. 19 - Left terminal carotid bifurcation located higher (at the level of C4 vertebra), the right carotid bifurcation occurring at the ½ superior level of C5 vertebra. The occipital and facial arteries have close origins creating together with the higher-located carotid the image of a trident (lateral section)

Fig. 21 - Left common carotid artery, "U"-shaped terminal bifurcation

The morphological characteristics at the level of the common carotid bifurcation were studied on 54 cases. I found out that, most frequently, that is in 26 cases (48.15% of the cases), the bifurcation of the common carotid had the shape of the letter "V". I ascribed two variants to this aspect: in 18 cases (33.33% of the cases) the bifurcation took the shape of a wide "V", while in 8 cases (14.81% of the cases) it resembled a tight "V" shape, with the two branches closer to one another. In 12 cases, (22.22% of the cases), the external and internal carotids had an adjacent ascending course, being joined on a length of 1-2 cm or even up to their conjunction. In 8 cases (14.81% of the cases), the two arteries overlapped at the level of the bifurcation, the external carotid artery having an anterior position.

Also in 8 cases (14.81% of the cases), a peculiar aspect was encountered: at the level of their bifurcation, the two arteries created a "U" shape. The internal carotid had an initially horizontal course with a lateral orientation for a length of approximately 3 mm, after

which it took a vertical course up to below the conjunction with the external carotid.

Fig. 22 - "U"-shaped bifurcation of common carotid, the internal carotid having a 3-4-mm horizontal course, changing then to a vertical course, away from the external carotid. The external carotid is vertical, and its diameter at origin is equal to the diameter of the internal carotid in its vertical segment. In its horizontal segment, the internal carotid has a larger diameter, corresponding to the carotid sinus.

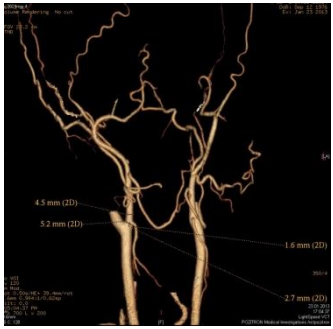


Fig. 23 - The right external carotid at origin (below the origin of the superior thyroid artery) has a diameter of 5.2 mm, and above the origin of the superior thyroid artery it has a diameter of 4.5 mm; the superior thyroid artery has a diameter of 1.6 mm, its origin being situated 2.7 mm above the carotid bifurcation.

I studied **the diameter of the external carotid artery at its origin** on 60 CT angiograms. I studied it in comparison to the diameters of the internal and common carotid arteries. I learned that, most frequently, in 48 cases (80% of the cases), the diameter of the external carotid artery was smaller than the one of the internal carotid artery. In 8 cases (13.33% of the cases), the diameter of the external carotid artery was the same size as the one of the internal carotid artery, while in the remaining 4 cases (6.67% of the cases), the diameter of the external carotid artery was larger than the one of the internal carotid artery.

I found out that the diameter of the right external carotid artery at origin ranged between 4-4.5mm, and the diameter of the left external carotid artery ranged between 3.6-6.4 mm. In relation to the common carotid which gave off the external carotid, the latter had a

diameter smaller by 1.6-2.1 mm on the left side and by 1.2-2.2 mm on the right side.

I noticed that the diameter of the right common carotid ranged between 6-6.7 mm, and the diameter of the left common carotid between 5.8-7.8 mm.

I learned that the diameter of the right internal carotid ranged between 6-7.7 mm while the diameter of the left common carotid ranged between 4.2-8 mm.

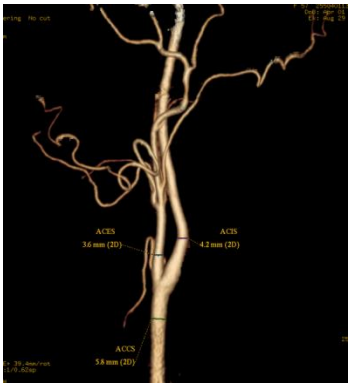


Fig. 24 -. The left common carotid artery has a 5.8-mm diameter; the left internal carotid has a 4.2-mm diameter, and the external carotid has a 3.6-mm diameter; the carotid sinus extends more on the internal carotid than on the common one.

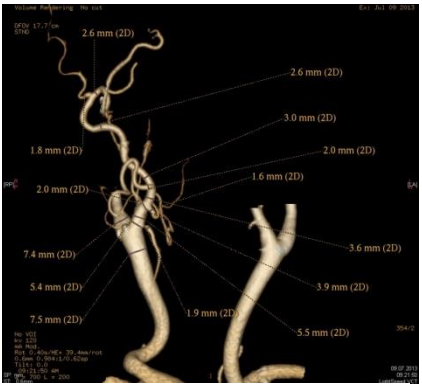


Fig. 26.Diameters of the carotid and of the collateral branches of the external carotid. Common carotid: 7.4 mm; external carotid below superior thyroid artery: 5.4 mm; superior thyroid artery: 1.9 mm;

I also measured the diameter of the external carotid artery above its origin from the common carotid, namely at different levels above or below the main collateral branches. Thus, above the superior thyroid artery I measured a diameter of 3.5-5.5 mm, which reads as an undercharge difference of 0.2-1.1 mm between the diameter of the external carotid artery caudal to the thyroid artery and the diameter of its cranial one; in only one case the cranial diameter was found to be 1 mm larger. Study shows that the carotid diameter below the lingual artery ranged between 3.3-4.7 mm, being 0.5-1.3 mm smaller than the diameter of the carotid at origin, and the

carotid diameter above the lingual artery ranged between 3.1-4.5 mm, being 0.8-1.8 mm smaller than the diameter of the carotid at origin. Within the caudal and cranial interval, in relation to the lingual artery, the carotid diameter was lower by 0.2-0.7 mm only in 6 cases (21,43% of cases) out of the 28 cases under scrutiny. I found the carotid diameter cranial to the facial ranging between 2-3 mm, the difference in size in relation to the origin being smaller by 0.8-2.7 mm. I encountered the most notable size variations of the external carotid in relation to the occipital artery, as the latter evinced the most numerous variations of the level of its origin. In relation to this artery, the external carotid above it measured a diameter of 1.9-3.9 mm, the difference compared to the carotid diameter at origin being 1.3-3 mm. With relation to the posterior auricular artery, the diameter of the external carotid above it is 1.5-1.9 mm, recording a 1.5-3.1 mm difference compared to the diameter at the origin. I measured the diameter of the external carotid immediately below its terminal branching and it ranged between 1.9-2.6 mm, with a 2.2-3.2 mm difference as compared to the carotid diameter at origin.

The length of the external carotid artery from its origin up to the bifurcation into the terminal branches measured between 68-82 mm.

Fig. 28 - Length of the right external carotid artery: 72.2 mm.

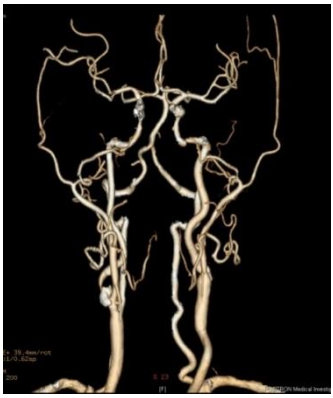


Fig. 31 - Right external carotid artery with a vertical course being crossed posteriorly by the left internal carotid, which is larger. The left external carotid artery has the shape of an italic “S”.

The course of the external carotid was traced on 60 cases. Most commonly, from the level of the common carotid bifurcation, the external carotid artery had a vertical course, encountered in 30 cases (50% of the cases). In 24 cases (40% of cases), the external carotid arteries had a supero-lateral oblique course, in 4 cases (6.67% of the cases) the external carotid artery described a curve with the convexity facing sideways, and in 2 cases (3.33% of the cases) it resembled a reversed italic "S".

There are situations in which the two carotids go joined closely to one another, the internal one being located on a plane slightly posterior to the external one, the two arteries remaining connected up to different levels: a. either on a short distance only, up to the level of the superior thyroid artery origin, when it has its origin in the external carotid artery, further away from the common carotid bifurcation; b. up to the beginning of the occipital artery, even when it does not have an origin in the external carotid below-lying; c. up to the conjunction with the internal carotid, the external carotid artery gives rise to all collateral branches, after the conjunction presenting the terminal branching; therefore, it is either a dense collateral branching or a high-level conjunction.

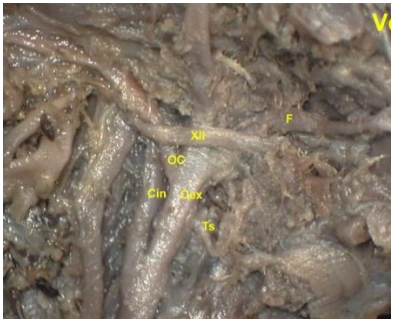


Fig. 32 - The two carotid arteries are joined in an ascending course up to the superior thyroid origin. The hypoglossal passes anterior to the external carotid above the origin of the facial which it crosses on the anterior face.

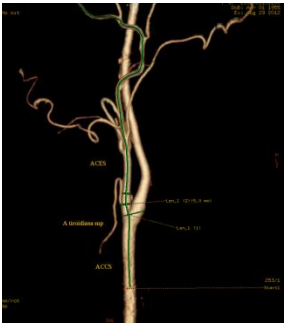


Fig. 34 - High-level conjunction of the two carotid arteries, after the origin of the posterior auricular artery. The carotid sinus goes further on the internal carotid. From its origin, the carotid describes a curve with the convexity facing sideways.

Frequently, after crossing the internal carotid artery, the external carotid artery changes its course, not only in terms of its leftward movement, but also describing a curve with lateral convexity, after which it acquires a vertical or oblique medial course. Other times, when it goes beyond the internal carotid, it can describe a curve with the concavity medially-orientated and subsequently becomes medially vertical or oblique.

Also, the carotid conjunctions on the two sides of the neck are not symmetrical; more commonly they occur at different levels, the left one being located at a higher level in comparison with the right one.

RELATIONS OF THE EXTERNAL CAROTID AND ITS COLLATERAL BRANCHES WITH THE HYPOGLOSSAL NERVE

I studied the relations between the external carotid artery with the hypoglossal nerve on a number of 54 cases. I learned that the hypoglossal nerve always crosses the external carotid artery, but at very variable levels in relation to the origins of its collateral branches.

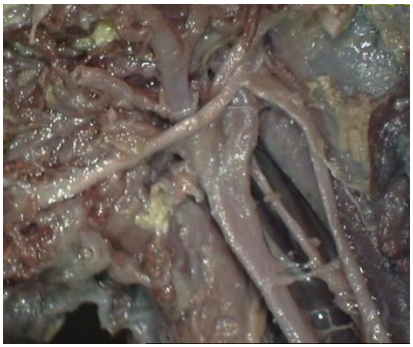


Fig. 36 - Hypoglossal nerve passes anterior to the left external carotid, under the origin of the facial artery and anterior to the lingual artery, which originate in the medial face of the carotid.

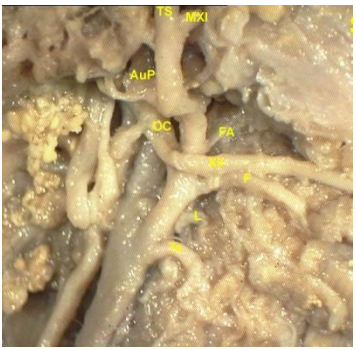


Fig. 37 – Hypoglossal nerve passes anterior to the origin of the occipital artery arising from the external carotid.

What is striking is the high number of cases in which the nerve passes under the occipital artery, raising it and causing a

noticeable superior convexity. Crossing of the external carotid artery by the hypoglossal nerve can occur at the following levels: a. under the origin of the lingual artery; b. under the origin of the facial artery; c. anterior to the lingual artery origin; d. below the occipital artery origin; e. under the posterior auricular artery origin; f. above the common carotid branching, as only the thyroid artery has its origin below the hypoglossal nerve.

DISCUSSIONS

TABLE 2 – THE LEVEL OF THE EXTERNAL CAROTID ARTERY ORIGIN

AUTHOR	LEVEL OF TERMINAL BRANCHING
Paturet	C4 or disk i.v. C3-C4
Rouvière	C4
Gray	C4
Bouchet	C4
Fontaine	C4 or disk i.v. C3-C4
Lippert	C4:65%; C5:17%
Frasin	C4
Diaconescu	C4
Personal cases	***C4:79.55%; C5:20.45%.***

In terms of *the size of the external carotid artery*, I found that it had a diameter between 4-5.4 mm on the right, and between 3.6-6.4 mm on the left; therefore right-left differences ranged from 0.4 to 1 mm. Paturet and Kamina found it to be 8 mm. So, in relation to the literature data, the results we found in carotid artery system size show that external right carotid artery represents 66.67% of the size of the common carotid artery from which it originates for the minimum size and 70.13% for the maximum size of these arteries. For the left external carotid, the minimum size represents 62.07% of the minimum size of the common carotid, and the maximum size represents 82.05% of the size of the originating common carotid. Compared to the corresponding internal carotid, right carotid has a size representing 66.67% for the minimum size and 70.13% for the maximum size. The left external carotid artery has a minimum size which is 85.71% of the left common carotid, and a maximum size representing 80% of the maximum size.

According to Kamina, the internal carotid artery is dilated at origin due to the carotid sinus. According to Paturet, at the end of the common carotid, the artery expands slightly, showing the carotid sinus, and according to Diaconescu the carotid sinus is situated at the level of common carotid bifurcation. At the level of the sinus, the vascular wall is rather more elastic than muscular. To Moore's mind, the carotid sinus is a slight dilatation of the initial segment of the internal carotid, which can stretch onto the common carotid. It is present in 90% of the cases in adults, beginning to develop after the age of 4 years.

What I found on the 32 carotid sinuses under study is that in 22 cases (68.75% of the cases), most frequently, the carotid sinus is noticeable at the level of the internal carotid, in 2 cases (6.25% of the cases) being reduced in size. The carotid sinus was present on the common carotid in 9 cases (28.125% of the cases) and on the external carotid in 6 cases (18.75% of the cases).

Fig. 41 - The left carotid sinus, present on the common carotid, extends on both carotids at about the same size. At the level of the right carotid, the carotid sinus extends on both carotids, being more voluminous on the internal carotid.

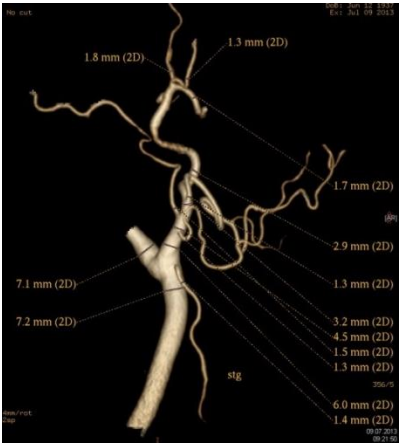


Fig. 43 - Diameters of the left external carotid system; external carotid: 6 mm; external carotid above lingual artery: 4.5 mm (a difference of 1.5 mm); external carotid above lingual artery: 3.2 mm (a difference of 2.8 mm); external carotid above facial artery: 2.9 mm (a difference of 3.1 mm).

According to Kamina, the diameter of the external carotid artery diminishes quickly after the origin of the first collateral branches; according to Paturet, Fontaine and Gray, the decrease of the diameter is marked after the origin of the third branch, which is usually the facial one. I noticed that an initial decrease in arterial size, which can be of up to 1.2 mm, can be encountered between the diameters of the carotid below and above the superior thyroid artery. This difference in diameter, compared to the arterial diameter at origin, increases with up to 2.8 mm above the lingual artery, the most dramatic decrease in diameter being located above the facial artery, of up to 3.2 mm; a 2.8-3.4 mm decrease is also noticed at the level of the terminal bifurcation.

The anterior crossing of the internal carotid artery by the external carotid may take place after giving off its collateral branches, the terminal bifurcation of the external carotid occurring lateral to the internal carotid. In these cases, the collateral branches of the external carotid arise at very close distances, aspect also reported by Kopuz, who describes an unusual branching of the external carotid artery: the thyroid artery arises exactly at the origin of the external carotid, and very close above there rise the lingual, facial and occipital arteries, the posterior auricular artery originating from the occipital artery. This anomaly was unilateral, without being accompanied by another vascular anomaly. I also found a similar case, in which the collateral branches of the external carotid emerged from under the crossing of the two carotids.

THE SUPERIOR THYROID ARTERY. I studied the superior thyroid artery origin on a number of 64 cases; most commonly, the superior thyroid artery originated in the external carotid artery, situation encountered in 34 cases (53.125% of the cases).

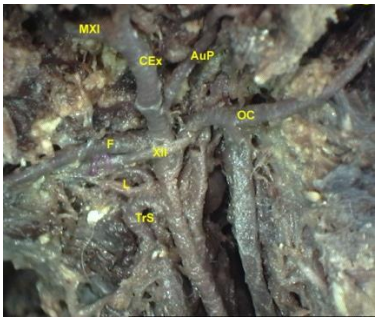


Fig. 44 - Left superior thyroid artery with a course in italic "S" shape, with its origin in the medial side of the external carotid.

Fig. 45 - Left superior thyroid artery with its origin in the medial side of the common carotid.

In 18 cases (28.125% of the cases) the superior thyroid artery had its origin in the common carotid, and in 12 cases (18.75% of cases), the thyroid artery had its origin in the carotid bifurcation, which thereby ends in trifurcation.

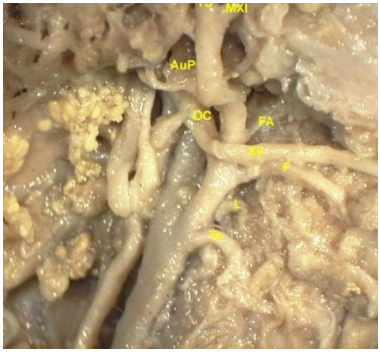


Fig. 46 - Superior right thyroid artery with its origin in a trifurcated common carotid artery.

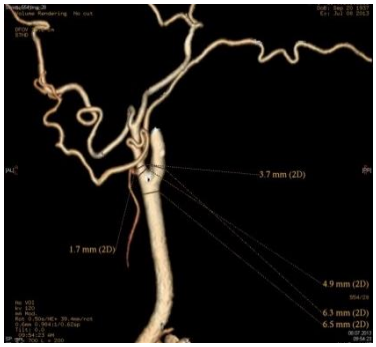


Fig. 51 - Diameters of the carotid system and of the left superior thyroid artery. The right common carotid: 6.5 mm; the internal carotid: 6.3 mm; the external carotid: 4.9 mm; the left superior thyroid: 1.7 mm; the external carotid above the superior thyroid artery: 3.7 mm.

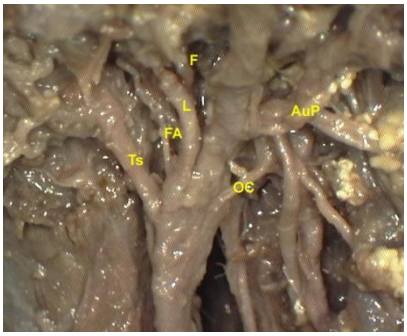


Fig. 54 - Arterial thyrolingual trunk (1.5 mm); with the exception of the posterior auricular artery which has its origin on the lateral side of the external carotid, 22 mm cranially away from the occipital, the other branches arise very closely to each other. The occipital artery has its origin at the same level as the lingual one.

I studied the **diameter** of the superior thyroid artery on a number of 40 arteries and I learned that it ranged between 1.3-1.9 mm.

I found that *the distance between the origin of the superior thyroid from the external carotid artery and the origin of the external carotid from the common carotid* ranged between 1-18 mm, the most common being of 1-3 mm in 9 cases (56.25% of the cases).

I encountered only one case of **left arterial thyrolingual trunk**.

DISCUSSIONS

TABLE 3 – ORIGIN OF THE SUPERIOAR THYROID ARTERY AS COMPARED WITH LIPPERT.

AUTHOR	ORIGIN OF EXTERNAL CAROTID	ORIGINE OF COMMON CAROTID	CAROTID BRANCHING
Lippert	50%	20%	20%
Personal cases	***53.125%***	***28.125%***	***18.75%***

TABLE 4 – ORIGIN OF THE SUPERIOAR THYROID ARTERY IN THE COMMON CAROTID

AUTHOR	PERCENTAGE %
Quain	14.10
Adachi	13.30
Faller	18
Poisel	6.41
Akyol	1
Lippert	20
Personal cases	***28.125***

Fig. 55 - Left superior thyroid artery resulted from the trifurcation of the common carotid.

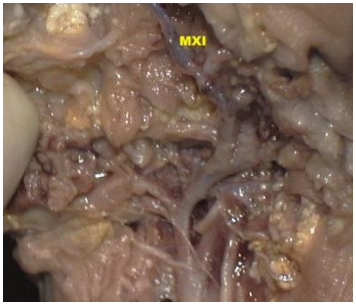


Fig. 56 - The lingual artery originates in the postero-medial face of the external carotid artery, and the facial artery on the medial face of the external carotid artery, the distance between them being of 1 mm, and the distance between the lingual artery and the carotid bifurcation being of 18 mm.

I found only one case of thyrolingual trunk, which also presented other vascular variations of the external carotid. According to Schunke, a thyrolingual trunk may arise from the external carotid in 4% of the cases.

THE LINGUAL ARTERY. I studied the lingual artery on a number of 54 cases; I found that it had its origin on the postero-medial face of the external carotid in 36 cases (66.67% of the cases), on the medial face of the external carotid in 15 cases (27.78%), and on the back of the external carotid in only 3 cases (5.55% of cases).

I studied the diameter of the lingual artery on a number of 30 cases and the measurements ranged between 1.3-2.2 mm.

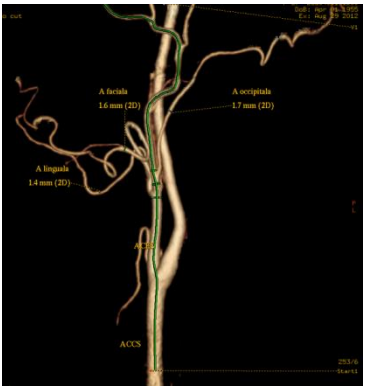


Fig. 62 - Right lingual artery with a diameter of 1.4 mm, the facial artery 1.6 mm and the occipital artery 1.7 mm.

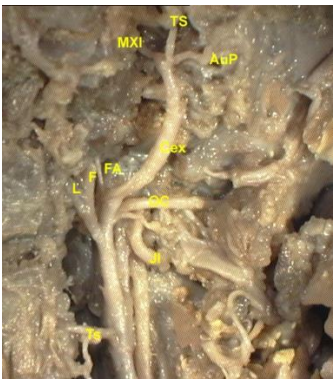


Fig. 64 - Common trunk lingual artery - facial artery. External carotid ending in trifurcation: maxillary artery, superficial temporal artery and posterior auricular artery.

I encountered three cases of arterial lingofacial trunk, two of which were on the left and one on the right side.

I came across a single case of arterial thyrolingofacial trunk, obtained by injection with plastic, followed by dissection.

DISCUSSIONS.

Lippert found the thyroid and lingofacial trunk from the external carotid in 18% of the cases, the thyrolingual trunk from the external carotid in 2% of the cases, the thyrolingual trunk from the common carotid in under 0.1% of the cases, and the thyrolingofacial trunk from the external carotid in less than 1% of cases. Gray found that the external carotid may give rise to a lingofacial trunk in 23% of cases or a thyrolingofacial trunk in 0.6% of the cases. I did not find any thyrolingual trunk, but I found three cases of lingofacial trunk, which would represent 5.55% of the 54 cases under study.

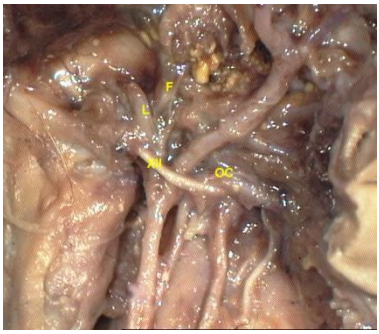


Fig.66 - Common lingofacial trunk.

THE FACIAL ARTERY

I studied 44 cases concerning the side of the external carotid artery which gives off the facial artery, noticing that in 28 cases (63.64% of the cases) its origin was on the medial side of the external carotid.

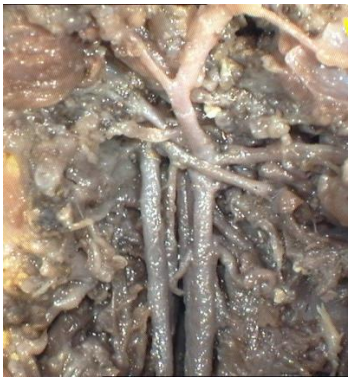


Fig. 68 - The facial artery arises on the medial side of the external carotid, cranially to the hypoglossal nerve by 2 mm.

Fig. 73 - Right arterial thyrolingofacial trunk.

I studied the relation between the origin of the facial artery and the hypoglossal nerve on 48 cases, finding that the facial artery had its origin caudal to the hypoglossal nerve in 23 cases (47.92% of the cases), above the hypoglossal nerve in 18 cases (37.5% of the

cases), and posterior to the hypoglossal nerve in 7 cases (14,58% of the cases).

DISCUSSIONS.

I studied the diameter of the facial artery on a number of 24 cases, finding it between 1.3-1.9 mm and not exceeding 2 mm as in the case of the lingual artery.

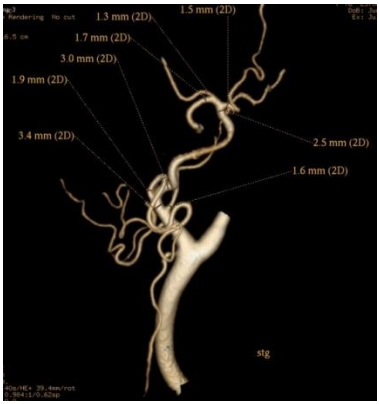


Fig 74 - Facial artery with 1.9 mm diameter, the diameter of the external carotid decreasing by 0.4 mm in the interval located cranially to the lingual artery and the facial artery.

With regard to the side of the external carotid that gives off the facial artery, Paturet and Rouvière found it most commonly on the anterior side, while I found it only in 4.54% of the cases.

I only encountered one case of thyrolingofacial trunk, which represents 2.27 of the 44 cases studied, while Lippert reported a percentage of less than 1% of the cases.

THE OCCIPITAL ARTERY. I studied 42 cases concerning the origin of the occipital artery in relation to the side of the external carotid which gave it off, finding that the occipital artery had its origin on the lateral side of the carotid in 21 cases (48.84% of the cases), on the postero-lateral side in 18 cases (41.86% of the cases), and on the antero-lateral and posterior sides in two cases (4.65% of the cases).

Fig. 76 - The left occipital artery originates on the lateral side of the carotid, at the intersection between the hypoglossal with the external carotid.

Fig. 80 - The origin of the occipital artery is located above the lingual artery.

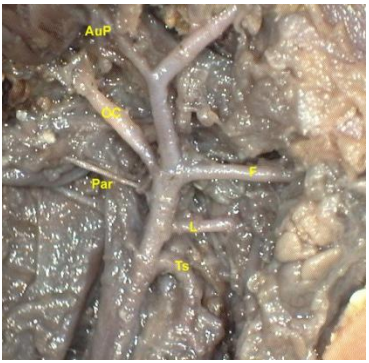


Fig. 81 - The origin of the occipital artery is located at the same level as the origin of the facial artery.

Fig. 83 - Occipital artery - posterior auricular artery trunk, originating on the antero-lateral side of the carotid, with an occipital branch arising from the auricular artery.

The relations of the occipital artery ratios with the lingual and facial arteries are very variable. Out of the 43 cases investigated, I found 8 cases (18.60% of the cases) in which the occipital artery had its origins situated between the origins of the lingual and facial arteries, 6 cases (13.95% of the cases) in which the occipital artery had its origin below the origin of the lingual and of the facial by way of consequence, and in 2 cases (11.11% of the cases) the origin of

occipital artery was located at the same level as the lingual artery. Also in 2 cases (11.11% of the cases), the origin of the occipital artery was located at the same level with the facial artery, both cases being on the right side (33.33% of the right arteries).

In 4 cases (9.30% of the cases), I found the existence of a common arterial trunk of the occipital artery and the auricular artery.

THE POSTERIOAR AURICULAR ARTERY

I studied the face of the external carotid from which the posterior auricular artery arises separately on a number of 34 cases, finding that the artery had its origin on the postero-lateral side of the carotid in 20 cases (58.82% of the cases), and on the postero-lateral side in 14 cases (41.18% of the cases).

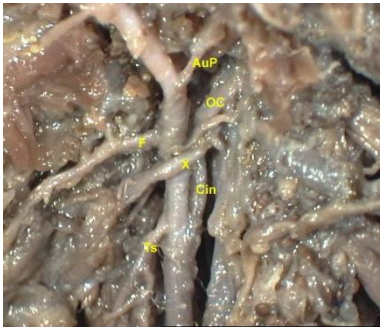


Fig. 91 - Left posterior auricular artery with origin on the lateral side of the external carotid.

The arterial occipitoauricular trunk that I encountered in 9.3% of the cases had its origin on the antero-lateral side of the external carotid in one case and on its postero-lateral side in another case, and on the lateral side of the external carotid in 2 other cases.

THE ASCENDENDING PHARYNGEAL ARTERY. I could trace it only on 11 cases, in 9 cases (81.82% of the cases) having a separate origin from the carotid artery; in 2 cases (18.18% of the cases) I encountered the existence of two arterial trunks: one in which the posterior auricular artery arises from a *lingofaciopharyngeal trunk* and another in which it arises from a *thyrofaringian trunk*.

Fig. 95 Right ascending pharyngeal artery, with origin in an arterial lingofaciopharyngeal trunk, which emerges from the postero-medial side of the carotid.

Fig. 96 - Left ascending pharyngeal artery with its origin in a thyropharyngeal trunk, with the origin of the medial side of the carotid.

TERMINAL BRANCHING OF THE EXTERNAL CAROTID

I studied the terminal branching of the external carotid on 32 cases, finding that in 20 cases (62.5% of the cases) it ends up by forking into the superficial temporal and maxillary artery, and in 12 cases (37.5% of the cases) it finishes by trifurcation into the maxillary artery, the superficial temporal artery and the transverse facial artery.

In 10 cases (38.46% of the cases), I found that the two arteries formed either an acute or an obtuse angle, and in 6 cases (23.08% of the cases) they formed a right angle.

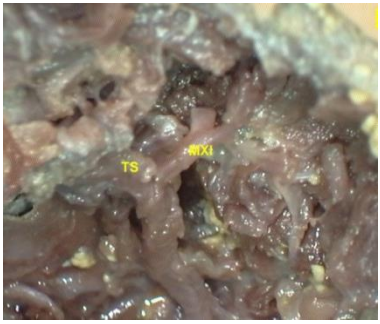


Fig. 98 - Terminal bifurcation of external carotid, with an obtuse angle formed by the two branches.

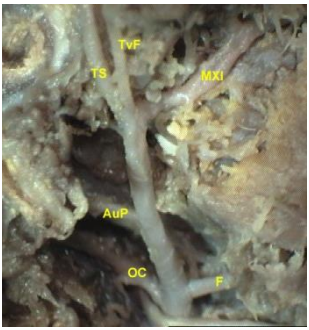


Fig. 99 - Terminal trifurcation of the external carotid with the maxillary artery in the medial position, the transverse facial artery in the median position and the superficial temporal artery in the lateral position. The maxillary and the superficial temporal arteries form a right angle. The transverse facial artery is closer to the superficial temporal artery.

Fig. 100 - Terminal trifurcation of the external carotid artery, the transverse facial artery being closer to the maxillary artery. The superficial temporal artery and the maxillary artery form an acute angle.

THE MAXILLARY ARTERY. I studied the diameter of the maxillary artery on a number of 25 cases, finding it between 1.5-2.7 mm. Comparing the diameter of the maxillary artery with the diameter of the superficial temporal artery on a total of 25 cases, I learned that the maxillary artery had a diameter larger than the superficial temporal artery diameter in 16 cases (64% of the cases), while in 6 cases

(24% of the cases) the maxillary artery had a smaller diameter than the one of the superficial temporal artery.

THE SUPERFICIAL TEMPORAL ARTERY. I studied the diameter of the superficial temporal artery on a total of 24 cases, finding it between 1.2-2.1 mm. The frontal branch of the superficial temporal artery had a diameter of 1.1-1.4 mm, and the parietal branch had a diameter of 1-1.5 mm.

Fig. 106 - Frontal and parietal branches of the superficial temporal artery have an equal diameter, the superficial temporal artery terminally branching at the level of the zygomatic arch.

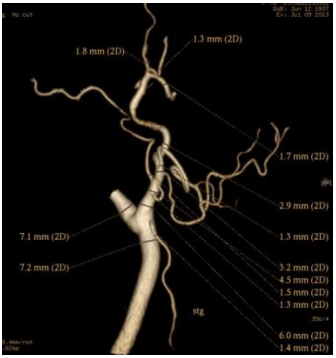


Fig. 107 - The diameter of the superficial temporal artery is 0.1 mm bigger than the diameter of the maxillary artery. The traverse facial artery, with its origin in the superficial temporal artery, has a diameter of 1.3 mm.

Fig. 108 - The right external carotid ends in bifurcation, the two branches forming a right angle, and the maxillary artery being more voluminous.

I studied the origin of the transverse facial artery on a number of the 32 cases; it emerges from the superficial temporal artery in 20 cases (62.5% of the cases), and it arises through the trifurcation of the external terminal carotid in 12 cases (37.5% of the cases). I measured the diameter of the transverse facial artery in a number of 18 cases, finding it between 1.1-1.8 mm.

DISCUSSIONS.

TABLE 5 – LEVEL OF THE TERMINAL BRANCHING OF THE SUPERFICIAL TEMPORAL ARTERY.

AUTHOR	ABOVE ZIGOMATIC ARCH (%)	ZIGOMATIC ARCH (%)	BELOW ZIGOMATIC ARCH (%)
Stock	60	32	8
Marano	88	4	4
Abul-Hassan	80	-	-
Czerwinski	62,5	26	11,5
Chen	86,5	3,8	9,6
Magden	80	10	8
Sahinoglu	61	14	7
Strauch	80	-	-
Atamaz Pinar	74,07	22,22	-
Personal cases	***88***	***12***	***-***

In what concerns the diameter of the superficial temporal artery and of its two terminal branches, I did not find any case of atrophy of one of these branches, Marano considering atrophy the situation in which the arterial diameter is less than 1 mm.

Fig. 109 - Double terminal parietal branch of the superficial temporal artery; the frontal branch originates in the suprazygomatic artery.

TABLE 6 - DIAMETERS OF SUPERFICIAL TEMPORAL ARTERY AND ITS TERMINAL BRANCHES (MM)

AUTHOR	STA	FRONTAL BRANCH	PARIETAL BRANCH
Stock (radiological)	1,89+/-0,68	1,38+/-0,4	1,29+/-0,5
Stock (cadaver)	2,03+/-0,33	1,74+/-0,51	1,83+/-0,34
Marano	2,2 (1-5)	-	-
Abul-Hassan	1,8-2,7	-	-
Chen	2,14+/-0,45	1,61+/-0,19	1,68+/-0,21
Magden	2,9 (2-4,1)	2,1 (0,8-3,1)	2,1 (0,9-3,1)
Strauch	1,8-2,7	-	-
Atamaz Pinar	2,73+/-0,51	2,14+/-0,54	1,81+/-0,45
Personal cases	**1,2-2,1**	**1,1-1,4**	**1-1,5**

CONCLUSIONS

Based on the present research project, it can be ascertained that there is marked variability of the terminal branching of the common carotid and of the diameter and course of the external carotid artery, detecting a frequent right-left asymmetry, as the details studied rarely evinced the same characteristics. The statistical differences between the results found by me and the existing data in the literature consulted are due mainly to the total number of cases on which they worked as well as to the working methods employed. In relation with diameters, the differences are due to the fact that I conducted most of my research on CT angiograms, while most of the authors worked with cadavers that were preserved in formalin or injected, procedures that vitiate the results, or with radiological or echographic methods which provide results different from CT angiographic methods.

The diameter of the external carotid is decreasing progressively, depending on the thickness of branches that it gives off, the difference between the origin of the external carotid and its terminal branching being of up to 2.8 mm.

The increased percentage of the superior thyroid artery originating outside the external carotid (46.875% of cases) is to be noted. When the superior thyroid artery originates in the carotid bulb, its diameter is larger, so that it seems that the common carotid ends in trifurcation. According to Sébileau's old claim (quoted by Paturet), this disposition is inconvenient for the ligature of the external carotid at origin because, when you pass a thread above the origin of the superior thyroid artery, there is sometimes a risk of common carotid ligature anterior to its terminal branch.

Having in view the increased percentage of common carotid termination through trifurcation (the origin of the superior thyroid artery at this level), I propose that the expression **terminal branching** should be used when talking about the common carotid in general and the terms of bifurcation or trifurcation only in those particular situations.

The course of the superior thyroid artery depends on the level of its origin, the cases with transverse and ascending courses

being encountered more often when the origin of the artery was at level of the common carotid or at the level of the terminal branching of the common carotid. This criterion also dictates the side of the artery giving origin to the superior thyroid; so, in the cases in which the origin of the artery was at the level of the carotid termination, the artery had its origin only on the medial side, while in the cases in which the thyroid artery had its origin at the level of the common carotid (71.43% of the cases), the artery had its origin on the medial and postero-medial side.

The lingual artery, on both sides, is ascertained to have a tendency for its origin on the postero-medial side of the carotid, noticeable in 66.67% of cases. I detected that the left lingual artery often has a larger diameter that the right one.

Most frequently, the facial artery has its origin on the medial side of the carotid (63.64% of the cases), more often on the right side, that is with 19.93% more than on the left side. The fact that the facial artery often has a diameter greater than that of the lingual artery (often having the largest diameter in the collateral branches) explains why the diameter of the external carotid decreases the most after giving origin to it. I found the difference between the diameter of the external carotid above the lingual artery and the diameter of the external carotid above the facial artery ranging between 0.7-1.6 mm, which is the greatest decrease in the diameter of the external carotid after giving origin to one of its collateral branches.

There are cases in which the diameter of the occipital artery is larger than that of the facial artery and in which the diameter of the external carotid artery decreases slightly or is equal to the diameter above the facial artery.

The occipital artery is distinguished by the high variability in the level of its origin from the external carotid, as its origin can be located at the level of any of the carotid collateral branches. The occipital and posterior auricular arteries originate most frequently from the postero-lateral and lateral sides of the carotid; only at the level of the occipital artery, the origin was situated on the antero-lateral side in two cases and on the posterior side in two other. As for the posterior auricular artery, there is a highly remarkable percentage of the location of the artery origin on the postero-lateral side, the right one having its origin only on the postero-lateral side the carotid (100% of the cases).

What is meaningful for the terminal branching of the external carotid is that the right angle between the maxillary artery and the

superficial temporal artery was encountered only on the right side (75% of the right arteries).

Because the external carotid ends very frequently in three branches (37.5%), just like in the case of the common carotid, I propose that the expression **terminal branching** should be used when talking about the external carotid in general and the terms of bifurcation or trifurcation only in those particular situations.

A very interesting aspect is the relation between the hypoglossal nerve and the collateral branches of the external carotid. Only the posterior auricular artery always had its origin cranially to the hypoglossal nerve. The other collateral branches of the carotid frequently had their origin located above the hypoglossal nerve. Thus, the lingual artery arises from the carotid below the hypoglossal nerve in 25% of the cases, and the facial artery in 37.5% of the cases. The occipital artery originates above the hypoglossal nerve in 35.71% of the cases, to which 14.28% of the cases are added in which the origin was located at the intersection with the hypoglossal nerve and in 7.14% of the cases the origin of the artery was covered by the nerve, which gives a total of 57.13% of the cases in which the occipital artery does not have its origin in the region of Farabeuf's triangle. This situation justifies fully the description of the Guyon (Morestin) triangle for locating the area of origin of the collateral branches of the external carotid, the posterior belly of the digastric having a constant location in relation to the hypoglossal nerve.

Another important aspect for the morphologist, for the radiologist and especially for the surgeon is the presence of the arterial trunks encountered: thyrolingual, lingofacial, lingofaciopharyngeal and occipitoauricular, which can raise problems during surgical interventions if not diagnosed prior to operations.

Not all aspects have been studied on a significant number of cases, hence explaining maybe why some of the issues raised in the literature consulted are not encountered in the present study. But when approaching a topic for study, it is impossible to come across all the aspects that it may present, not to mention that it is impossible to exhaust it. An aspect that has not been encountered or that has been omitted can be mentioned or even discovered at any other time.

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