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Arrangement and prevalence of branches in the external carotid artery in humans

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Summary

The external carotid artery originates branches to face structures. The superior thyroid, lingual and facial arteries are originated from this vessel as artery trunks or separately. The aim of this study was to determinate the arrangement frequency of these artery branches. For this, thirty six (36) hemi-heads of adult cadavers from both genders were studied. The anatomic parts were fixed in 10% of formalin and dissected. The superior thyroid, lingual and facial arteries were analyzed in terms of their origins. The superior thyroid, lingual and facial arteries originated separately from the external or common carotid artery in 77.8% of the cases. A linguofacial trunk was observed in 19.9% of the cases and a thyrolingual trunk in 2.8%. A thyrolinguofacial trunk was not observed. In 51.2% cases the superior thyroid artery originated directly from the external carotid artery, in 45.3% from the bifurcation of the common carotid artery, and in 3.5% from the common carotid artery. Thus, the superior thyroid, lingual and facial arteries more frequently showed a separate origin from the external or common carotid artery. Among the combined artery trunks, the linguofacial trunk was most frequently observed, followed by the thyrolingual trunk. The superior thyroid artery originated more frequently from the external or common carotid artery; however, it also could emerge from the bifurcation of the common carotid artery.

Key words

Human anatomy; external carotid artery.

Introduction

The two common carotids are the main arteries that supply the head and neck with blood (Standring, 2008; Dogan *et al.*, 2010), and in the higher part of the neck they divide into two branches, the external and internal carotids. According to Standring (2008), in 8 possible levels between the second and the sixth cervical vertebra, the common carotid supplies 1) the exterior of the head, face, and most part of the neck and 2) structures within the cranial cavity (Standring, 2008), with numerous variations. Knowledge of the neck vessels anatomy is important for surgical and radiological purposes (Lucev *et al.*, 2000).

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The right and left common carotid arteries differ in origin and size (Standring, 2008), and generate the external carotid in the carotidal trigon lateral to the superior border of the thyroid cartilage in 50% of cases (Zümre, 2005; Standring, 2008), at the inferior border of this cartilage in 12.5%, at the inferior border of the hyoid bone in 25%, and at the superior border of this bone in 12.5% (Lucev *et al.*, 2000).

In general, the bifurcation level mentioned above is the same as the intervertebral disc between the third and fourth cervical vertebra (Zümre *et al.*, 2005; Standring, 2008), where the external carotid inclines laterally and posteriorly and passes through the space between the angle of the mandible and the mastoid process, then divides into the superficial temporal and maxillary arteries (Standring, 2008).

While ascending, the external carotid generates branches to the face with many variations; in order, the thyroid superior, lingual and facial arteries (Lockhart *et al.*, 1983; Costa *et al.*, 2000; Sobotta, 2000; Madeira, 2004; Wolf-Heidegger, 2006; Schunke *et al.*, 2007). Variations have been reported; the superior thyroid, lingual and facial arteries can form combined arterial trunks (Figun and Garino, 1989; Gray, 1995; Dangelo and Fattini, 2000; Schunke *et al.*, 2007). The superior thyroid artery is especially important since it may form a supra-isthmic anastomosis that supports blood flow to the brain in cases of occlusion of the common carotid artery (Macchi and Catini, 1995).

A thyrolingual trunk or a thyrolinguofacial trunk are sometimes observed (Basmajian, 1993; Shangkuan *et al.*, 1998; Shima *et al.*, 1998; Lins *et al.*, 2005; Zümre *et al.*, 2005; Schunke *et al.*, 2007); however, a trunk including the maxillary artery instead of the lingual artery is rare (Gray, 1995).

These studies have indicated large variations in the neck vessels, in a region where many surgical procedures are conducted. For example, cervical artery dissection is an important cause of stroke due to intramural hemorrhage (Muller *et al.*, 2000). Therefore, it is very important for surgeons to know the exact frequency and variations of the arteries in the areas where they have to operate (Panagouli *et al.*, 2011). Variations are common in the neck vessels and may create danger to surgery (Sanjeev *et al.*, 2010; Panagouli *et al.*, 2011). Indeed, physicians must take care and consider all possible variation in the neck arteries before and during surgery and in cases of ultrasonic or radiologic examination (Mamatha *et al.*, 2010); failure to consider those variations may generate fatal errors (Lucev *et al.*, 2000).

Moreover, anatomical information on the head and neck arteries is important for less invasive treatment of diseases in the neck and head region (Satogami *et al.*, 2009). In general, knowledge of angio-architecture contributes to skillful segmentectomies, helping to preserve tissue, perform better surgery, reduce both anesthesia and hemorrhage, and consequently save human lives (Di Dio, 1999). However, despite variations in the carotid and its branches, only a few studies investigated these variations, mostly as case-reports (Sanjeev *et al.*, 2010), and inconsistent information has been reported (Lo *et al.*, 2006).

In the present study, the external carotid artery and its anterior branches were studied focusing on the prevalence of trunks and on the origin of the superior thyroid artery in reference to the bifurcation level of the common external carotid, using human cadavers in Brazil.

Material and methods

Thirty-six hemi-heads (19 right and 17 left) of different adult cadavers from both genders were studied. These cadavers were initially fixed in formalin 10% and then kept in glycerin 5%. The hemi-heads were dissected to expose the arterial branches of the head and neck. The arrangement of the superior thyroid, lingual and facial arteries was analyzed in terms of variations of origin. This study was conducted as previously approved by the Department of Morphology of the Institute of Biological Sciences, Federal University of Goias, Brazil.

Statistical analysis was performed using the Biostat 2009 software [version 5.8.4.3, 2010]. The present data and those from previous literature were compared by Kruskal-Wallis and non-parametrical χ^2 tests (Vieira, 2003; Aversi-Ferreira, 2009; Aversi-Ferreira *et al.*, 2011).

Results

Separate superior thyroid, lingual and facial arteries were observed in 77.8% cases (Table 1).

Separate origins were clearly identified for these vessels (Figs 1 and 2-I). However, formation of trunks was also observed (Fig. 2-II, Table 2). A linguofacial trunk

Table 1 - Origin of the superior thyroid, lingual, and facial arteries in the hemi-heads of humans in Brazil.

Hemi-heads	Separate	Arterial trunks	
		Linguofacial	Thyrolingual
Right	15 (41.7%)	3 (8.33%)	1 (2.8%)
Left	13 (36.1%)	4 (11.2%)	0
Total	28(77.8%)	7 (19.4%)	1 (2.8%)

A thyrolinguofacial trunk was never observed.

Table 2 - Prevalence of superior thyroid, lingual, and facial arteries in previous studies.

Trunks and respective frequencies (%)			Authors	Country of origin of studies
Thyrolingual trunk	Linguofacial trunk	Thyrolinguofacial trunk		
-	-	3	Adachi (1928)	Japan
-	20	-	Lucev *et al.* (2000)	Croatia
2.5	7.5	0	Ozgur *et al.* (2008)	Turkey
3.5	31	0	Shintani *et al.* (1999)	Japan
2.7	18.92	0	Sanjeev *et al.* (2010)	India
2.5	20	2.5	Zümre *et al.* (2005)	Turkey
2.8	19.4	0	This work	Brazil

p<0.05 by Kruskal-Wallis and χ^2 test, indicating similarity between samples.

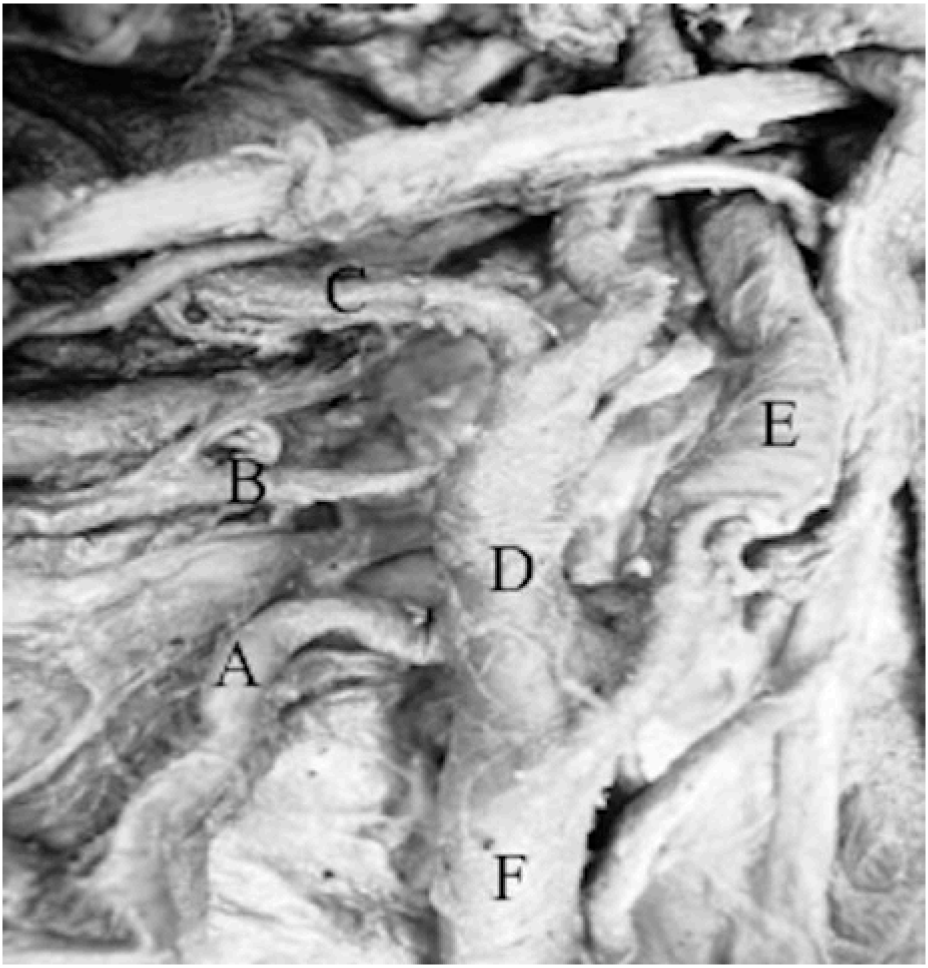

Figure 1 – Arrangement of the cervicofacial arterial branches in adult human. The superior thyroid (A), lingual (B) and facial (C) arteries have separate origins from the external carotid artery (D). The internal carotid (E) and common carotid (F) arteries are also shown. Magnification of 1.9 times the natural size.

was observed in 19.4% hemi-heads (Table 2). It most frequently originated from the external carotid artery (Table 3), and in some cases from the common carotid artery bifurcation (Fig. 2-III, Table 3). A thyrolingual trunk (Fig. 2-IV, Table 2) was observed only in one case (2.8%, Table 1, 2). A geminated origin of the three arterial branches to form a thyrolinguofacial trunk was not observed in the present study.

The origin of the superior thyroid artery occurred at three possible levels (Table 3). The most frequent origin was, in 51.2% cases, the external carotid artery superior to the common carotid artery bifurcation (Fig. 1). This vessel originated from the common carotid artery bifurcation (Fig. 2-I) in 45.3% cases, and from the common carotid artery in 3.5% cases (Fig. 2-II and III).

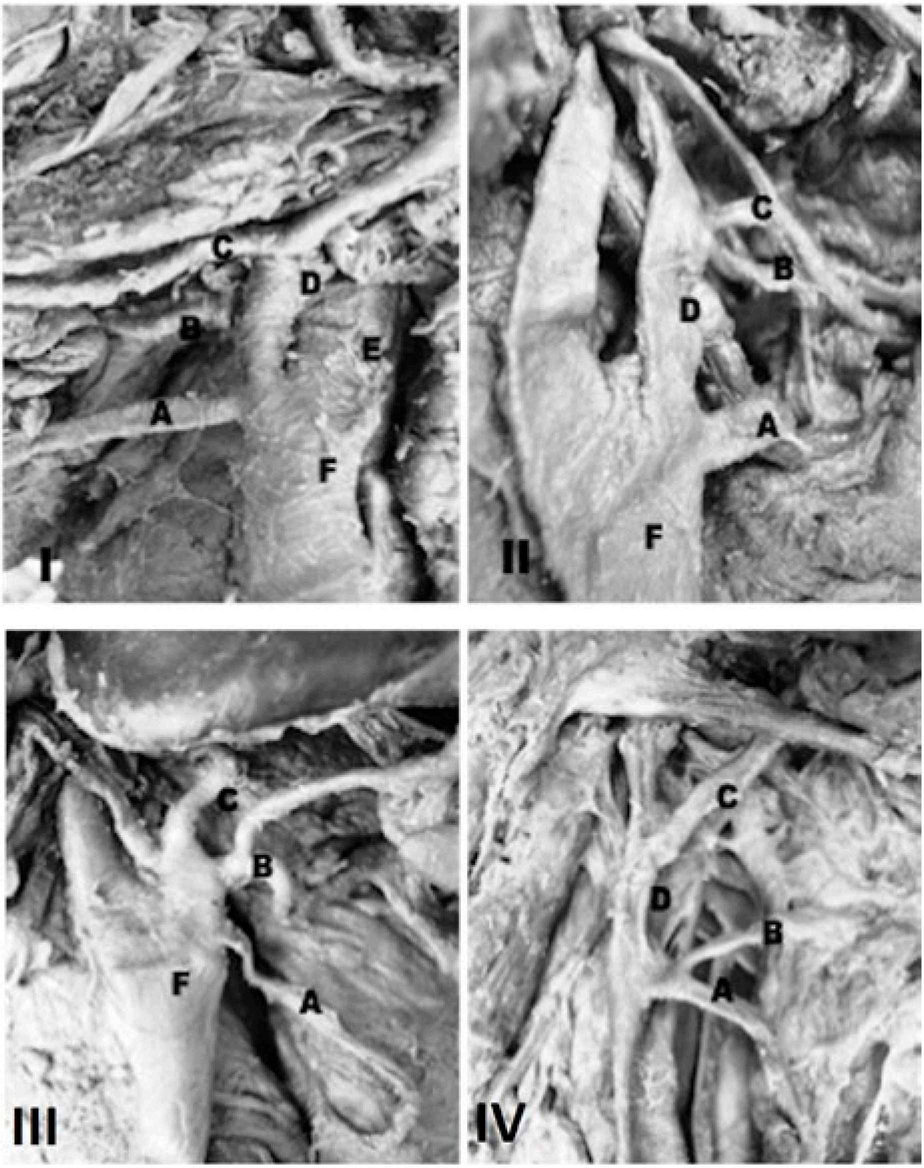

Figure 2 - Arrangement of the cervicofacial arterial branches in human adults. Magnification of 1.4 times the natural size.

I - Superior thyroid (A), lingual (B) and facial (C) arteries with separate origins from the external carotid artery (D). The superior thyroid artery emerges at the common carotid artery bifurcation (F) into external and internal (E) carotid arteries.

II - Lingual (B) and facial (C) arteries originating close to each other from the external carotid artery (D). Superior thyroid artery (A) originating from the common carotid artery (F).

III – Linguofacial trunk emerging from the common carotid artery bifurcation (F) and giving origin to the lingual (B) and facial (C) arteries. Superior thyroid artery (A) emerging from the common carotid artery.

IV - Thyrolingual trunk emerging from the external carotid artery (D) and giving origin to the superior thyroid (A) and lingual (B) arteries. Facial artery (C) with separate origin.

Table 3 - Prevalence of the origin of the superior thyroid artery in relation to the bifurcation level of the common external carotid.

Level of origin (%)			Authors	Country of origin of studies
Carotid bifurcation	External carotid artery	Common carotid artery		
0	64.86	35.14	Sanjeev *et al.* (2010)	India
2	46	52	Harrigan and Deveikis (2009)	USA
1.5	46.2	52.3	Lo *et al.* (2006)	New Zealand
22.5	30	47.5	Lucev *et al.* (2000)	Croatia
22	68	10	Banna and Lasjaunias (1990)	Saudi Arab
40	25	35	Ozgur *et al.* (2008)	Turkey
70	25	5	Zümre *et al.* (2005)	Turkey
45.3	51.2	3.5	This work	Brazil

$p<0.05$ by Kruskal-Wallis and χ^2 test, indicating similarity between samples.

The comparison of these data with previous ones from the literature did not show any significant difference (Tables 2 and 3).

Discussion

Statistical analysis

From statistical analysis, it may be argued that the great variability in the origin of carotid artery branches occurs in equal measure among different population and it is not yet possible to speculate which and how genetic, environmental and random factors influence the anatomical architecture of these vessels.

Separate origins

In the present study, separate origins of the superior thyroid, lingual, and facial arteries were observed in 77.8% cases, which was greater than in some previous studies (Zümre *et al.*, 2005) but in agreement with Sanjeev *et al.* (2010), who reported that separate origins occur most frequently to these vessels.

The present results are consistent with what one reads in the anatomic textbooks indicating separate origins for these vessels (Lockhart *et al.*, 1983; Gardner *et al.*, 1988; Costa *et al.*, 2000; Sobotta, 2000; Madeira, 2004; Wolf-Heidegger, 2006; Standring, 2008); some authors reported the origins without mentioning the existence of arterial trunks (Figun and Garino, 1989; Gray, 1995; Dangelo and Fattini, 2000; Schunke *et al.* 2007). Researchers should take into account the different origins of cadavers (ethnic and genetic differences) and the methodologies employed, because large differences have been observed between data sets even from the same country (Table 3).

In the present study, the superior thyroid artery most frequently originated from the external carotid artery (51.2%). In 45.3% of the cases, the origin of the superior thyroid artery occurred at the level of the common carotid artery bifurcation, and least frequently from the common carotid artery (3.5%). The finding about the superior thyroid artery is important because, in case of occlusion of common carotid, the superior thyroid artery becomes a possible route of collateral circulation through the supra-isthmic anastomosis (i.e. a large anastomosis between the superior and inferior arteries), that can support substantial blood supply to the brain (Macchi and Catini, 1995).

Artery trunks

The prevalence of each trunk in the present study was largely consistent with those in the previous studies. The linguofacial trunk was observed in 19.4% cases in this work. This frequency ranges from 7.5 to 31% according to other authors (Basmajian, 1993; Shangkuan *et al.*, 1998; Shima *et al.*, 1998; Shintani *et al.*, 1999; Lucev *et al.*, 2000; Lin *et al.*, 2005; Zümre *et al.*, 2005; Ozgur *et al.*, 2008; Sanjeev *et al.*, 2010). The thyrolingual trunk has been reported in the previous literatures from 2.5 to 3.5% cases (Adachi, 1928; Zümre *et al.*, 2005), while the prevalence observed in the present study was 2.8%. Substitution of the lingual artery by a branch from the maxillary artery has been described as a rare variant (Gray, 1995), which was never found in this study.

From a statistical point of view, the prevalence of each trunk is small and similar among the previous and present studies. Indeed, as shown by the frequencies of the arterial trunks, which ranged from 2.5 to 3.5% for the thyrolingual trunk, from 0.0 to 3.0% for the thyrolinguofacial trunk, and from 7.5 to 31% for the linguofacial trunk. The variation among the studies in the different countries is small, except for the linguofacial trunk because of two extreme data obtained from different countries (Table 2).

Embryological consideration

When separate origins were observed, the maximum distance between the lingual and facial arteries was 14.56 mm, and that from the lingual artery to the superior thyroid artery was 39.04 mm (Lins *et al.*, 2005). The interval between these vessels is quite variable (Lins *et al.*, 2005); sometimes no interval was observed in 2.5% of human fetuses (i.e., formation of the thyrolinguofacial trunk) (Zurme *et al.*, 2005), as also reported in an atlas (Schunke *et al.*, 2007). However, statistical analysis did not indicate any significant difference in the prevalence of the combined trunks among the different studies, either by Kruskal-Wallis (p>0.748) or χ^2 tests (p<0.5578). This would be in keeping with the angiogenesis theory, which suggests that confluence of the vessels and vessels with large diameter are more common in fetuses compared with adults.

This might depend on the higher body, and organ, surface-to-volume ratio in fetuses than in adults, which might favor proportionally larger vessels in fetuses. Aversi-Ferreira (2008) have proposed that the exponential relation between increase in volume and increase in surface may explain the higher metabolism rate of small animals as compared with that of big ones and of children as compared with human adults; indeed, during body growth the area increases proportionally to the square and the volume proportionally to cube of the diameter (Penereiro, 2010). The area is strictly correlated with energy expenditure, feeding and gas distribution in organisms and this might explain why the area of arteries in fetuses is wider than adults. For example, the thyrolinguofacial trunk occurs most frequently in fetuses and tends to disappear in adults. Moreover this region, where the common carotid divides into external and internal carotid arteries, is a site of marked histological transition since an elastic (type III) artery generates muscular (type I) arterial branches (Hughes, 1943).

Conclusions

Variations in the arrangement of the studied vessels have not been correlated with derangement of blood perfusion in the face and neck. From the stand point of surgical procedures and of radiological and ultrasonic examination, knowledge of arterial anatomical variations in the cervical region are required to avoid errors in invasive procedures in this region which can be fatal (Kruger, 1984; Bavitz *et al.*, 1994; Lucev *et al.*, 2000; Mamatha *et al.*, 2010; Sanjeev *et al.*, 2010, Satogami *et al.*, 2009).

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