Eur. J. Anat. 19 (1): 37-42 (2015)

Carotid bifurcation - clinical relevance

Blanca Mompeó[1] and Eva Bajo[2]

[1]Departamento de Morfología, Universidad de Las Palmas de Gran Canaria, Spain and
[2]Instituto de Medicina Legal de Las Palmas de Gran Canaria, Spain

SUMMARY

Common carotid artery bifurcation (CCAb) branches and topography of surrounding structures are essential for diagnosis and surgical procedures in the neck. The aim of this study was to add evidence of the variability found in the CCAb region relative to bifurcation location, arterial carotid branches and surrounding structures in the studied sample. This study was performed on 38 CCAbs from 19 cadavers. The CCAbs were located at the level of the superior border of the thyroid cartilage (TC) in 63.15% (24/38) of the cases, and at the hyoid bone (HB) level in 36.85% (14/38) of the sample. There was asymmetry between the right and the left side in 10.52 % (2/19) of the cadavers. The superior thyroid artery (STA) arose from the common carotid artery (CCA) or the CCAb in 34.21% (13/38) of the cases. The ascending pharyngeal artery (APA) arose from the internal carotid artery (ICA) in 2.6% (1/38) of the cases. The vagus nerve (VN) ran posterior to the CCAb in 89.48% (34/38) of the cases, and anterolateral in 10.58% (4/38) of the cases. The carotid body (CB) was found posterior in the angle of the CCAb in 73.68% (28/38) of the cases. The carotid bifurcation region showed a considerable variability in the studied sample. The findings of the study, together with other previously published studies, should be taken into consideration by physicians and surgeons to avoid clinical complications.

Key words: Common carotid artery bifurcation – Branches in carotid bifurcation – Surrounding structures in carotid bifurcation – Anatomical common carotid artery variation – Carotid triangle

Corresponding author: Blanca Mompeó. Departamento de Morfología, Universidad de Las Palmas de Gran Canaria, Facultad de Ciencias de la Salud, Dr. Pasteur s/n, 35016 Las Palmas de Gran Canaria (Spain). Tel: +34 928453414; Fax: +34 928453420. E-mail: bmompeo@dmor.ulpgc.es

INTRODUCTION

Neck surgery is frequently performed and requires a clear understanding of the anatomical common carotid artery bifurcation (CCAb), its branches, and its relation to surrounding structures. Knowledge of the CCAb region is essential in diagnostic imaging, radical neck dissection, cervical discectomy, carotid endarterectomy, catheterization and aneurysms (Ozgur et al., 2008; Hayashi et al., 2005; Gulsen et al., 2009). The significance of variation in the location of the CCAb, and consequently, of the carotid sinus, has also been considered in relation to pressure resulting from neck palpation and consecutive activation of parasympathetic, inhibition of sympathetic nuclei and possible occurrence of syncope (Strickberger et al., 2006; Folino, 2007). In addition, a sexual or racial feature in the CCAb has been considered as a possible cause of differences in the atherosclerotic plaque distribution (Koch et al., 2009; Schulz and Rothwell, 2011).

The main landmarks for the CCAb are the superior edge of thyroid cartilage (TC), and the hyoid bone (HB). However, the following have also been described in relation to the CCAb: a) a lower and a higher bifurcation (Ord and Ward-Booth, 1986; Vitek and Reaves, 1973; Testut and Latarjet, 1974); b) CCA agenesis (Testut and Latarjet, 1974; Robert and Gerald, 1978); and c) non-bifurcating CCA (Testut and Latarjet, 1974).

It has been classically considered that the common carotid artery (CCA) does not supply cervical collateral branches (Testut and Latarjet, 1974). However, it has been lately shown that those circumstances are not exceptional (Toni et al., 2004; Hayashi et al., 2005; Lo et al., 2006; Kloset et al., 2008; Ozgur et al., 2008; Vazquez et al., 2009; Natsis et al., 2011; Ongeti and Ogeng'o, 2012).

The internal carotid artery (ICA) has usually been considered not to emit branches in the neck. How-

Submitted: 19 April, 2014. *Accepted:* 23 September, 2014.

ever, branches emerging from this artery, which could be cause of misdiagnosis, have been observed in some cases (Teal et al., 1973; Testut and Latarjet, 1974; Hayashi et al., 2005; Iwai et al., 2012).

The present study examined the anatomy of the CCAb region relative to arterial branches and surrounding structures: vagus nerve (VN) and carotid body (CB).

MATERIALS AND METHODS

Thirty-eight hemi-necks belonging to 19 cadavers from 15 men and 4 women, aged ranged between 35-80 years, were studied. All of them were undergone necropsy in the Instituto de Medicina Legal de Las Palmas de Gran Canaria (Spain), and a total of 38 common carotid artery bifurcation regions (CCAbs) were dissected. The following baseline data were recorded: age, sex, death cause, and history of chronic disease. The causes of death were as follows: 47.36% (9/19) myocardial infarction, 15.78 % (3/19) pulmonary embolism, 26.31% (5/19) accident or suicide, and 10.5% (2/19) by other causes. Besides, 26.31% (5/19) of the sample had ischemic heart disease or hypertension antecedents. All of them were Spanish.

The parameters studied were: 1) location of the CCAb in relation to the main landmark in the neck, superior edge of the TC and body of the HB; 2) relationship between the VN and the CCAb; 3) location of the CB; 4) branches in the CCA and the CCAb, and in the proximal segment of the ICA and the external carotid artery (ECA) (1cm of length). The cadavers were lying supine and the neck was in extension following the corporal axis without any lateral deviation. The arteries were located and dissected from both sides of the neck, and then they were extracted with surrounding structures and photographed.

RESULTS

We could document the following findings:

1. Position of the CCAb relative to the anatomical landmarks (superior edge of the TC and body of the HB). The CCAb occurred at the superior border of the TC in 63.15% (24/38) of the cases, and at the HB in 36.85% (14/38) of the sample. The bifurcation occurred at the TC level in 54.11% (13/24) (10 males and 3 females) of the sample on the left side and in 45.83% (11/24) (9 males and 2 females) of the sample on the right side. When the bifurcation occurred at the HB level, 57.14% (8/14) (6 males and 2 females) of the cases were located on the right side, and 42.85% (6/14) (5 males and 2 females) on the left side.

In 10.52% (2/19) of the necropsied subjects, the level of CCAb was not alike on both sides. In those cases, the bifurcation level on the right side was at the HB, and on the left side at the superior edge of the TC.

2. Localization of the VN. The vagus nerve was located posterior in the medium line of the CCAb in 36.85% (14/38) of the cases, posteromedial in 13.15% (5/38), posterolateral in 39.47% (15/38), and lateral to the CCAb in 10.52% (4/38) of the cases.

3. Carotid branches. 39.47% (15/38) of the sample showed some type of anatomical variation related to the classically described arrangement of arterial branches. They were located on the left side in 60% (9/15) of the cases, and on the right side in 40% (6/15) of the cases.

Our sample showed the following carotid branch variations (Fig. 1):

a) Origin of the superior thyroid artery (STA) from the CCAb or the CCA instead of the external carotid artery (ECA) in 86.66% (13/15) of the variations, i.e., 34.21% (13/38) of the total cases). STA arose from the CCAb in 69.23% (9/13) of the variations, i.e., 23.68% (9/38) of the total cases. In the most of the cases (8/13), STA arose from the anterior side and, only in one case (1/13), from the medial side. STA arose from the CCA in 30.76% (4/13) of the variations, i.e., 10.52% (4/38) of the total cases.

b) STA emerged from a common trunk with other branches in 6.66% (1/15) of the variations, i.e. 2.63% (1/38) of the total cases. Arteries in the trunk were identified as superior thyroid artery (STA), superior laryngeal artery (SLA), and lingual artery (LA). SLA emerged from the origin of the STA.

c) One arterial branch was observed emerging from the medial wall of the ICA in 6.66% (1/15) of the variations, i.e., 2.63% (1/38) of the total cases. This branch was identified as ascending pharyngeal artery (APA) (Fig. 1B).

The variations related to the classically described branch arrangement occurred in 41.66% (10/24) of the cases, as the CCAb was located at the level of the TC, and in 35.71% (5/ 14) of the sample, as the CCAb was located at the level of the HB. The variations appeared bilaterally in 6 of the 19 nec-

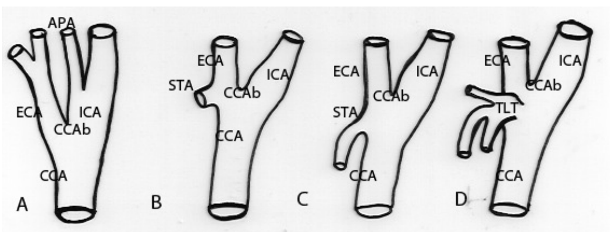

Fig. 1. Schematic representation of the four branch variations observed in our sample: **(A)** APA arising from the ICA; **(B)** STA emerging from the CCAb; **(C)** STA arising from CCA and **(D)** a TLT emerging from CCA. CCA, common carotid artery; ECA, external carotid artery; ICA, internal carotid artery; CCAb, bifurcation common carotid artery; STA, superior thyroid artery; APA, ascending pharyngeal artery; TLT, thyrolingual trunk.

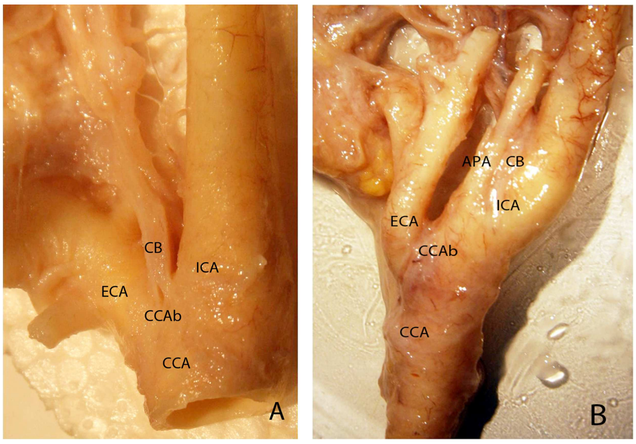

Fig. 2. Posterior view of two right common carotid bifurcations. **(A)** CB is joined to the posterior part of the angle between ECA and ICA in the CCAb. **(B)** APA emerges from the ICA and CB is located between ICA and APA. CCA, common carotid artery; ECA, external carotid artery; ICA, internal carotid artery; CCAb, bifurcation common carotid artery; APA, ascending pharyngeal artery; CB, carotid body.

ropsied subjects, and were unilateral in 3 of the 19. In the bilateral variations, the pattern was similar on both sides in 33.3% (2/6), and different in 66.66% (4/6) of the cases.

4. Carotid Body. CB morphology was variable and showed to be different in shape and size in each sample. It was located in the angle of the CCAb, being posterior in the angle of bifurcation in 73.68% (28/38) of the cases. It was located in the central zone of the angle in 7.89% (3/38) of the sample, in the anterior part of the angle in 7.89% (3/38) of the cases, and in the base of the ICA or the ECA in 10.52% (4/38) of the cases (Fig. 2A-B).

DISCUSSION

One of the most frequently studied aspects in the carotid region has been the level of CCAb. The knowledge of the exact location of CCAb before a surgical procedure could warn surgeons about possible vulnerable structures whose location could vary in relation to the CCAb (Assadian et al., 2004; Lo et al., 2006). It is said that the CCAb is located mostly at some place between the superior border of the TC and the HB. However, there is no agreement about the percentage of cases in each location (Table 1). There is also disagreement in the level of bifurcation between the left and the right side in the same subject. We found, in our sample, 10.52% of the cases with apparent predominance of CCAb at the level of the HB on the right side, and at the CT level on the left side, while Klosek (2008) considered that 67-88% of the cases were not alike, and Lo et al. (2006) observed asymmetric bifurcation level in 48% of the cases.

It has been considered that the differences in the geometry and bifurcation level of CCAb on studied subjects could be the consequence of a possible race/ethnic difference (Koch et al., 2009; Hayashi et al., 2005). In that regard, Table 1 shows that different populations have been considered by different studies, but the results in similar studied populations do not seem to be alike. Therefore, our point of view is that the following explanations should also be considered:

1. Sample size (which is one of the main problems that may arise when comparing different statistical studies). In that regard, table 1 shows that samples similar to those used by Hayashi (2005) and Klosek (2008), or those used by Ozgur et al. (2008) and our data (2014) yield different results.

2. Landmark chosen for bifurcation location. The studies of Lo et al. (2006) and Ozgur et al. (2008), as well as our study, considered the TC and the HB to be the landmarks of the CCAb location, while Hayashi et al. (2005) and Klosek and Rungruang (2008) used the cervical vertebras to determine the CCAb location. Although it is generally considered that there is an equivalent level between the cervical vertebra and the two main used landmarks, TC and HB (Moore et al., 2010; Standring, 2008), a lack of one strict common method for the authors to determine the exact level of bifurcation could affect the obtained results

Table 1. CCAb location level according to the studied population and the sample size. Correspondence of TC and HB to the cervical vertebras (Standring, 2008; Moore, 2009)

Author	Population	(N)	% of the cases studied					
			Thyroid Cartilage (TC) (C3-C4)			Hyoid Bone (HB) (C3)		
			Superior edge	Body	Below TC	Body	Greater horn HB	Above HB
Lo (2006)	New Zealand	36	39	40	_	6	15	_
Ozgur (2008)	Turkish	20	----------------- 27.5 -----------------			------------------- 72.5 -----------------		
Hayashi (2005)	Japanese	49	_	_	_	Mostly		
Klosek (2008)	Thai	43	20.93	_	66.26	------------------12.79 -------------------		
Our results	Spanish	19	--------------- 63.15 ---------------			---------------------36.85 ---------------		

N): number of cadavers used in the study.

(Koch et al., 2009).

3. Several other circumstances to determine the level of CCAb, such as the conditions of the specimen studied, should also be taken into consideration: a) fresh or fixed cadavers; b) position of the neck after fixation (if appropriate); c) angle of inclination and possible lateralization of the head in relation to the neck; d) depth of the neck dissection, where the relationship between the structures could be lost; e) instruments used to trace the line of the CCAb in relation to the landmark; f) position and morphology adopted by the bifurcation itself, etc. Our point of view is that all these circumstances could also give different results in the observations, and they should be referred to in the studies. Our specimens were fresh and necropsied within 24-48 hours after death; the specimens of Lo et al. (2006) were prepared for anatomical dissection courses with 4% of phenolic acid and 0.5% of formaldehyde; the subjects of Hayashi et al. (2005) were formalin fixed cadavers, and there was no reference about the condition of the cadavers in the study performed by Klosek and Rungruang (2008).

Another uncertainty in the carotid region is the arterial branching in the carotid triangle. We found, in relation to the classically described pattern, an incidence of 39.47% in branch variation. The most frequently observed variations were those in relation to the STA. The STA origin is considered an important surgical landmark and, although the STA is classically described to be originated mainly from the anterior surface of the ECA, many published studies have reported STA emerging from the CCA or the CCAb in a considerable number of cases. Our results showed an incidence of STA emerging from the CCA or the CCAb in 34.21% of the cases, similarly, to some extent, to that of Hayashi et al. (2005), who found the emergence of STA from the distal portion of the CCA in 30% of Japanese population. However, that incidence was lower than that found by Lo et al. (2006), Ozgur et al. (2008), Vazquez et al. (2009), Natsis et al. (2011), and Anagnostopoulou and Mavridis (2014). Those authors found the origin of the STA in the CCA or the CCAb in a proportion of 52.3%, 65%, 75%, 61% and 57.34% of the cases, respectively.

Our sample showed the emergence of one trunk with three branches emerging from the anterior wall of the CCA below the bifurcation level in one case, i.e., 2.63% of the cases under study. Those branches were identified as STA, SLA and LA. Thyrolingual trunk (TLT) arising from the CCAb or the CCA has been described as a “case report”, among other authors, by Lemaire et al. (2000), Jadhav et al. (2011), and Kapre et al. (2013). In most of the cases (0.7-0.3%), TLT arises from the ECA, and the frequency of origin of TLT from the CCA has been reported in 0.1% of cases (Toni et al., 2004).

Following the classifications proposed by Vazquez et al. (2009) and Anagnostopoulou and Mavridis (2014) with regard to the origin of the STA (Table 2), it is possible to observe that the percentage of cases showing the origin of the STA in different studies, in relation to the carotid arteries, is quite different. The disagreement among studies could be attributed to three main reasons: 1) sample size; 2) studied population; 3) limits considered for the CCAb. The sample size is one of the main problems that may arise when comparing different statistical studies. In that regard, the study of Vazquez et al. (2009) seems to be the most reliable since it includes the widest sample, but it was not possible to find a relationship between the size sample and the results obtained in other studies.

With regard to the above second given reason, although the race/ethnic condition has been widely

Table 2. Origin of the superior thyroid artery (STA)

Authors	Population	Size (N)	% of cases			
			ECA	CCA	CCAb	Common trunks
			Type III*	Type II*	Type I*	Type IV*
			Type B**	Type A**	Type C**	
Hayashi (2005)	Japanese	49	70	---------- 30 ------		1
Lo (2006)	New Zealand	36	46.2	---------- 52.3 ----		_
Kloset (2008)	Thai	43	66.5	---------- 33.5 ----		_
Ozgur (2009)	Anatolian	20	25	35	40	2.5
Vazquez (2009)	British	108	23	27	49	0.6
Natsis (2011)	Greek	50	39	12	49	3
Ongeti (2012)	Kenyan	46	80.4	10.9	2.2	6.5
Anagnostopoulou (2014)	Greek	68	42.64	38.23	19.11	(Included in B**)
Our results	Spanish	19	65.78	10.52	23.68	2.63

Relation to the studied population, the sample size and the proposed classification: 1) Vazquez et al. (2009)* (Type I, STA origin from carotid bifurcation; type II, STA origin from common carotid artery; type III, STA origin from external carotid artery; Type IV, STA origin from a common thyrolingual or thyrolinguofacial trunk); and 2) Anagnostopoulou and Mavridis (2014)** (Type A, STA origin from CCA; type B, STA origin from ECA; type C, STA origin from CCAb. These authors considered common trunks to be a subtype of type B). Size (N), number of cadavers.

argued to explain the differences, there was no apparent relationship between the population included in the studies and the origin of the STA.

Finally, the limits considered for the CCAb could be, at least in part, in relation to the unlike results. In this study, the CCAb was considered just the arterial portion located in the angle formed between the ECA and the ICA, and 5 mm proximal in the CCA. Once the ECA and the ICA were formed, they were not considered CCAb anymore.

The identification of possible extracranial branches of the ICA is essential to minimize surgical complications (Loftus and Quest, 1995; Cavalcanti et al., 2009). In this sense, although the APA is classically said to be arising from the back of the ECA, it has also been described to be originated from the CCA and the ICA (Teal et al., 1973; Hayashi et al., 2005). We could observe in one case, i.e., 2.63% of our sample, one branch which was emerging from of the ICA that was identified as the APA. Hayashi et al. (2005) observed this variation in 2% of the cases in Japanese population. The presence of non-usual origin of APA has also been described to be coincident with a very high bifurcation of CCA (Gluncic et al., 2001). In our study, the presence of such non-usual origin was coincident with the CCAb at HB level, but the APA emerged from the ICA and not from the CCA as it was the case described by Gluncic et al. (2011).

The VN injury in endarterectomy procedures has been reported in 2.5% of the cases (Ferguson et al., 1999). In those procedures, the VN should be isolated from carotid artery (CA) and protected to avoid injury (Evans, 1982). In our studied sample, the nerve was observed dorsal to the ICA and the CCAb in 89.47 % of the cases. The proportion was similar to that obtained by Cavalcanti et al. (2010), who found a posterior location of the VN in 82.8% of the necks dissected, but it was quite different from the proportion obtained by Lo et al. (2006), who found a location posterior to the nerve in 99 % of the cases. The data above referred to should alert surgeons that the VN is located anterolateral in 1-17% of the CCAb.

In relation to the CB location, our data are totally coincident with those obtained by Khan et al. (1978), who found that the CB was located in the CCAb in most of the cases (86%). In addition, our sample showed that the CB was related to the ECA, or it was located between the APA and the ICA, as the APA arose from the ICA.

Conclusions: The CCAb and surrounding structures show a great variability in the carotid triangle region and therefore, physicians and surgeons should take all the anatomical possibilities into consideration. A thorough knowledge of the structure arrangement is essential to avoid neck surgical complications. More detailed studies (with a greater number of specimens), using dissection and image techniques, should be performed in further research of the CCAb and surrounding structures.

REFERENCES

ANAGNOSTOPOULOU S, MAVRIDIS I (2014) Emerging patterns of the human superior thyroid artery and review of its clinical anatomy. *Surg Radiol Anat*, 36: 33 -38.

ASSADIAN A, SENEKOWITSCH C, PFAFFELMEYER N, ASSADIAN O, PTAKOVSKY H, HAGMÜLLER GW (2004) Incidence of cranial nerve injuries after carotid eversion endarterectomy with a transverse skin incision under regional anaesthesia. *Eur J Vasc Endovasc Surg*, 28: 421-424.

CAVALCANTI DD, REIS CV, HANEL R, SAFAVI-ABBASI S, DESHMUKH P, SPETZLER RF, PREUL MC (2009) The ascending pharyngeal artery and its relevance for neurosurgical and endovascular procedures. *Neurosurgery*, 65 Supl 6: 114-120.

CAVALCANTI DD, GARCIA-GONZALEZ U, AGRAWAL A, TAVARES PLMS, SPETZLER RF, PREUL MC (2010) A clear map of the lower cranial nerves at the superior carotid triangle. *World Neurosurg,* 74: 188-194.

EVANS WE, MENDELOWITZ DS, LIAPIS C, WOLFE V, FLORENCE CL (1982) Motor speech deficit following carotid endarterectomy. *Ann Surg*, 4: 461-463.

FERGUSON GG, ELIASZIW M, BARR HW, CLAGETT GP, BARNES RW, WALLACE MC, TAYLOR DW, HAYNES RB, FINAN JW, HACHINSKI VC, BARNETT HJ (1999) The North American symptomatic carotid endarterectomy trial: surgical results in 1415 patients. *Stroke*, 30: 1751-1758.

FOLINO AF (2006) Cerebral auto-regulation and syncope: victim or executioner? *Heart,* 92: 724-726.

GLUNCIC V, PETANJEK Z, MARUSIC A, GLUNCIC I (2001) High bifurcation of common carotid artery, anomalous origin of ascending pharyngeal artery and anomalous branching pattern of external carotid artery. *Surg Radiol Anat*, 23: 123-125.

HAYASHI N, HORI E, OHTANI Y, OHTANI O, KUWAYAMA N, ENDO S (2005) Surgical anatomy of the cervical carotid artery for carotid endarterectomy. *Neurol Med Chir*, 45: 25-30.

GULSEN S, CANER H, ALTINORS N (2009) An anatomical variant: low-lying bifurcation of the common carotid artery, and its surgical implications in anterior cervical discectomy. *J Korean Neurosurg Soc*, 45: 32-34.

IWAI T, IZUMI T, INOUE T, MAEGAWA J, FUWA N, MITSUDO K, TOHNAI I (2012) Occipital artery arising from the anterior aspect of the internal carotid artery identified by three-dimensional computed tomography angiography. *Iran J Radiol*, 9: 103-105.

JADHAV SD, AMBALI MP, PATIL RJ, ROY PP (2011) Thyrolingual trunk arising from the common carotid bifurcation. *Singapore Med J*, 52: e265-266.

KHAN Q, HEATH D, SMITH P (1988) Anatomical variations in human carotid bodies. *J Clin Pathol*, 41: 1196-

1199.

KAPRE M, MANGALGIRI AS, MAHORE D (2013) Study of thyro-lingual trunk and its clinical relevance. *Indian J Otolaryngol Head Neck Surg*, 65: 102-104.

KLOSEK SK, RUNGRUANG T (2008) Topography of carotid bifurcation: considerations for neck examination. *Surg Radiol Anat*, 30: 383-387.

KOCH S, NELSON D, RUNDEK T, MANDREKAR J, RABINSTEIN A (2009) Race-ethnic variation in carotid bifurcation geometry. *J Stroke Cerebrovas Dis*, 18: 349-353.

LEMAIRE V, JACQUEMIN G, MEDOT M, FISSETTE J (2001) Thyrolingual trunk arising from the common carotid artery a case report. *Surg Radiol Anat*, 23: 135-137.

LO A, OEHLEY M, BARTLETT A, ADAMS D, BLYTH P, AL-ALI S (2006) Anatomical variations of the common carotid artery bifurcation. *Anz J Surg*, 76: 970-972.

LOFTUS CM, QUEST DO (1995) Technical issues in carotid artery surgery. *Neurosurg*, 36: 629-647.

MOORE KL, DALLEY AF, AGUR AMR (2009) *Clinically Oriented Anatomy*. 6th edit. Lippincott Williams and Wilkins, Philadelphia.

NATSIS K, RAIKOS A, FOUNDOS I, NOUSSIOS G, LAZARIDIS N, NJAU SN (2011) Superior thyroid artery origin in Caucasian Greeks: A new classification proposal and review of the literature. *Clin Anat*, 24: 699-705.

ONGETI KW, OGENG'O JA (2012) Variant origin of the superior thyroid artery in a Kenyan population. *Clin Anat*, 25: 198-202.

ORD RA, WARD-BOOTH RP (1986) Anomalies of the common carotid artery: a rare complication of radical neck dissection. *Br J Oral Maxilloc Surg*, 24: 405-409.

OZGUR Z, GOVSA F, OZGUR T (2008) Anatomic evaluation of the carotid artery bifurcation in cadavers: implications for open and endovascular therapy. *Surg Radiol Anat*, 30: 475-480.

OZGUR Z, GOVSA F, CELIK S, OZGUR T (2009) Clinically relevant variations of the superior thyroid artery: an anatomic guide for surgical neck dissection. *Surg Radiol Anat*, 31: 151-159.

ROBERTS LK, GERALD B (1978) Absence of both common carotid arteries. *AJR*, 130: 981-982.

SCHULZ UGR, ROTHWELL PM (2011) Sex differences in carotid bifurcation anatomy and the distribution of atherosclerotic plaque. *Stroke*, 32: 1525-1531.

STANDRING S, editor (2008) Gray's Anatomy: *The Anatomical Basis of Clinical Practice*. 40th edit. Churchil Livingstone, Edinburgh.

STRICKBERGER SA, BENSON DW, BIAGGIONI I, CALLANS DJ, COHEN MI, ELLENBOGEN KA, EPSTEIN AE, FRIEDMAN P, GOLDBERGER J, HEIDENREICH PA, KLEIN GJ, KNIGHT BP, MORILLO CA, MYERBURG RJ, SILA CA (2006) AHA/ACCF Scientific statement on the evaluation of syncope. *Circ*, 113: 316-327.

TEAL JS, RUMBAUGH CL, SEGALL HD, BERGERON RT (1973) Anomalous branches of the internal carotid artery. *Radiol*, 106: 567-573.

TESTUT L, LATARJET A (1974) *Anatomía Humana*. 9th edit. Salvat, Barcelona.

TONI R, DELLA CASA C, CASTORINA S, MALAGUTI A, MOSCA S, ROTI E, VALENTI G (2004) A meta-analysis of superior thyroid artery variations in different human groups and their clinical implications. *Ann Anat*, 186: 255-262.

VÁZQUEZ T, COBIELLA R, MARANILLO E, VALDERRAMA FJ, McHANWELL S, PARKIN I, SAÑUDO JR (2009) Anatomical variations of the superior thyroid and superior laryngeal arteries. *Head and Neck*, 10: 1078-1085.

VITEK JJ, REAVES P (1973) Thoracic bifurcation of the common carotid artery. *Neuroradiol*, 5: 133-139.