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VARIANT TERMINATION OF THE COMMON CAROTID ARTERY: CASES OF QUADRIFURCATION AND PENTAFURCATION

Julius A Ogeng'o, Musa Misiani, Adel Malek, Martin Inyimili, Acleus Murunga, Kevin Ongeti

Correspondence to Prof. Julius Ogeng'o, Department of Human Anatomy, University of Nairobi PO Box 30197 00100 Nairobi. Email: jogengo@uonbi.ac.ke

ABSTRACT

Knowledge of variant termination of common carotid artery is important to prevent inadvertent vascular injury during surgical, interventional and diagnostic radiological neck procedures. The variations show population differences but there are scanty data from the black African populations. Further, though trifurcations have been reported, quadrifurcations and pentafurcations are hitherto undocumented. This study therefore examined the pattern of termination of 208 left common carotid arteries in the black Kenyan population by cadaveric dissection at the Department of Human Anatomy, University of Nairobi. The conventional bifurcation into internal and external carotid arteries occurred in only 128 (61.5%) of cases. Trifurcation occurred in 66 (31.7%), quadrifurcation in 11(5.4%) and pentafurcation in 3 (1.4%). In all cases of trifurcation, superior thyroid artery was the third branch. The common carotid artery quadrifurcated into external, internal carotid, superior thyroid and ascending pharyngeal arteries. The pentafurcations comprised internal carotid, external carotid, superior thyroid, occipital and posterior auricular arteries. These findings imply that the black Kenyan population has over 38% frequency of variant termination of common carotid arteries comprising trifurcation, quadrifurcation and pentafurcation which may complicate radical neck dissection, vascular surgery, carotid catheterization and selective embolization. Surgeons and radiologists should approach the common carotid bifurcation with extra caution.

Key words: Common carotid, Trifurcation, Quadrifurcation, Pentafurcation, African, Ascending Pharyngeal, Occipital, Posterior auricular arteries

INTRODUCTION

Knowledge of variant termination of the common carotid artery (CCA) is important to prevent inadvertent vascular injury during radical neck dissection, cervical discectomy, carotid artery catheterization for diagnostic or interventional radiological procedures, reconstruction of aneurysms and carotid endarterectomy (Lucev et al., 2000; Gluncic et al., 2001; Chitra, 2008; Ozgur et al., 2008, 2009; Ambali and Jadhav, 2012; Iwai et al., 2013). These variations can lead to severe, often fatal, complications if radiographic evaluation or surgical procedures are done without prior knowledge or one blood vessel is confused for the other, say ascending pharyngeal for internal carotid (Lucev et al., 2000; Chitra, 2008). They are also invaluable to radiologists in vascular image interpretation of head and neck region (Ambali and Jadhav, 2012). Some of the variant terminations of CCA, for example trifurcations, have been documented in many reports (Lucev et al., 2000; Marques et al., 2002; Chitra, 2008; Al – Rafiah et al., 2011; Gupta et al., 2014; Joshi et al., 2014). There are, however, hardly any reports of other variant patterns such as quadrifurcation and pentafurcation, which occur in other arteries (Ogeng'o et al., 2012; Ogeng'o et al., 2014). Further, even in the trifurcation, besides internal and external carotid arteries, the third artery is not universal, and the frequency shows ethnic variation (Toni et al., 2004; Natsis et al., 2011). Notably, these variations are

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hardly documented in black African populations. As neck surgery and carotid artery disease increase in Sub-Saharan Africa (Aswani et al., 2012; Oladapo et al., 2013), knowledge of termination pattern of CCA becomes increasingly important. In this study, therefore, we examined the pattern of termination of the common carotid arteries in a black Kenyan population.

MATERIALS AND METHODS

Two hundred and eight left common carotid arteries from cadavers of adult black Kenyans (104 male, 104 female) were studied by dissection at Department of Human Anatomy, University of Nairobi. Skin and fascia were removed from the side of the neck to expose sternocleidomastoid muscle, which was detached from both attachments. The body of the mandible was also removed to allow full access. The carotid sheath was opened and fibrofatty tissue and internal jugular vein removed. Nerves were retracted, the carotid bifurcation exposed and the branches traced to their destinations. Number of branches at the bifurcation was counted and each identified by tracing it to its destination. Photographs of representative patterns were taken using a high – resolution digital camera. Macrographs, and a table presented results.

RESULTS

All of CCA gave rise to internal carotid artery (ICA) and external carotid artery (ECA). Four patterns of termination were identified. Bifurcation (Figure 1A) was the most common (128; 61.5%). The rest (80; 38.5%) showed variant branching. The most common was trifurcation into ECA, ICA and superior thyroid artery (STA) (Figure 1B) (66; 31.7%). Quadrifurcation into ECA, ICA, STA and ascending pharyngeal artery (APA) (Figure 1C) and pentafurcation into ECA, ICA, STA, occipital artery (OA) and posterior auricular artery (PAA) (Figure 1D) were observed in 11 (5.4%) and 3 (1.4%) of the cases respectively [Table 1]. Gender differences were not statistically significant [p = 0.074]

Table 1: Branching pattern of left CCA in a black Kenyan population

Branching Pattern	Frequency	(%)
Bifurcation	128	(61.5)
Trifurcation	66	(31.7)
Quadrifurcation	11	(5.4)
Pentafurcation	3	(1.4)
Total	**208**	**100**

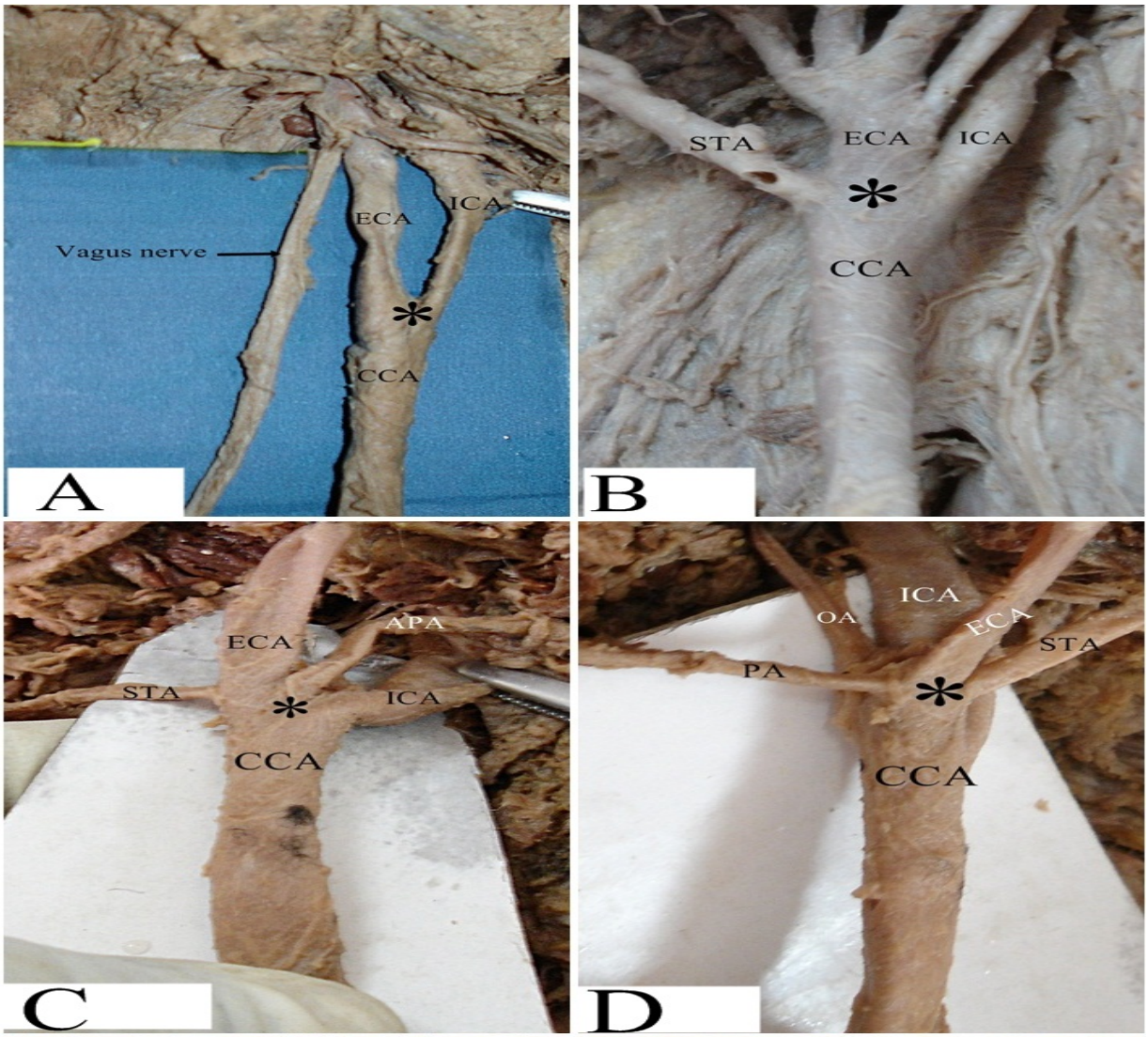

Figure 1 A - F: Macrographs showing branching pattern of left common carotid artery. A: Bifurcation (*) of the common carotid artery (**CCA**) into the internal carotid artery (**ICA**) and external carotid artery (**ECA**). Vagus nerve is also shown. **B**: Trifurcation (*) of the common carotid artery (**CCA**) into the internal carotid artery (**ICA**), external carotid artery (**ECA**) and superior thyroid artery (**STA**). Note the subsequent quadrifurcation of the external carotid. **C**: Quadrifurcation (*) of the common carotid artery (**CCA**) into the internal carotid artery (**ICA**), external carotid artery (**ECA**) and superior thyroid artery (**STA**) and ascending pharyngeal artery (**APA**). **D:** Pentafurcation (*) of the common carotid artery (**CCA**) into the internal carotid artery (**ICA**), external carotid artery (**ECA**) superior thyroid artery (**STA**), posterior auricular artery (**PA**) and occipital artery (**OA**).

DISCUSSION

The CCA usually divides into external and internal carotid arteries (Standring, 2008). Observations of the current study revealed, however, that this bifurcation only occurs in 61.5% of cases, 38.5% of the arteries being variant. This is comparable to 39%

frequency of variation among the Greeks (Natsis et al., 2011) and is concordant with prevailing literature reports that up to 49% of CCA terminations may be variant (Vasquez et al., 2009). These variations may result from disturbances of development of aortic sacs and third aortic arch such that the branchial arteries are displaced caudally towards the base of ventral pharyngeal arch (Lie, 1968; Dungan and Hieserman, 1996; Nakaoka and Matsuura, 2002). In these cases, arteries that usually branch from ECA arise from the carotid bifurcation in various combinations. In the current study, the variants comprised trifurcation, quadrifurcation and pentafurcation.

Trifurcation: This was the most frequent variation occurring in 31.7% of cases. Explicit accounts of common carotid trifurcation are only in the form of case reports (Gurbuz et al., 2001; Chitra, 2008; Jadhav et al., 2011; Sugavasi et al., 2012; Patel et al., 2014). Implied cases in which a third artery arises from the carotid bifurcation to constitute trifurcation have, nonetheless, been reported [Table 2]. These figures suggest that the frequency of a third branch from the carotid bifurcation shows population variability. A notable feature of the present study that in all cases, the third branch was the superior thyroid artery. This is concordant with literature reports from Caucasian and Indo – Asian populations (Vasquez et al., 2009; Natsis et al., 2011; Joshi et al., 2014; Gupta et al., 2014). This variation, should be considered during surgical procedures in the neck region such as thyroidectomy, emergency cricothyroidotomy, radical neck dissection, carotid catheterization, reconstruction of aneurysm and carotid endarterectomy (Ozgur et al., 2009)

Quadrifurcation: This variant occurred in 5.4% of cases. All of them comprised ECA, ICA, STA and APA. Basekim et al., 2004 reported a closely related case where the arteries that usually emanate from ECA, namely STA, APA and facial arose from the common carotid artery together with ICA. In this case, however, the ECA was absent. In the current study, the previously unreported finding is the simultaneous origin of STA and APA from the carotid bifurcation. The APA may separately arise from the carotid bifurcation in up to 5% of cases (Al – Rafiah et al., 2011). Knowledge of this variation is particularly important to avoid confusion with internal carotid, for example during selective embolization for carotid body tumors (Cavalcanti et al., 2008) and for proper dissection and clamping of the artery to avoid back bleeding during carotid endarterectomy and radial artery grafting (Umeoka et al., 2014).

Table 2: Frequency of trifurcation of the common carotid artery in different populations

Reference	N	Population	Frequency (%)	3rd Artery
Adachi and Hasebe, 1928	228	German	0.7	Occipital
Marques et al., 2002	110	Brazillian	1.8	Occipital
Gluncic et al., 2001	33	Croatian	1.8	Ascending pharyngeal
Hayashi et al., 2005	49	Japanese	2	Ascending pharyngeal
Vasquez et al., 2009	330	Spanish	49	Superior thyroid
Cavalcanti et al., 2011	112	American	5	Ascending pharyngeal
Natsis et al., 2011	100	Greek	39	Superior thyroid
Current study, 2013	**208**	**Kenyan**	**26.8**	**Superior thyroid**

Pentafurcation: The variation occurred in 1.4% of cases. We came across only one closely related case in which apart from ECA and ICA, a common linguo – facial trunk, occipital and ascending pharyngeal arteries originated from the carotid bifurcation (Kishve et al., 2011). In the current study, for all the 3 cases, the pentafurcation comprised ECA, ICA, STA, OA and PAA. Separate origin of the OA from carotid bifurcation has been reported in various studies (Adachi and Hasebe, 1928; Gurbuz et al., 2001; Marques et al., 2002; Chitra, 2008). This variation is important during arterial biopsy, scalp flap surgery and head and neck angiographic studies (Marques et al., 2002). Origin of PAA from carotid bifurcation, on the other hand, is seldom reported. Potential use of this artery as a donor for middle cerebral artery territory revascularization (Tokugawa et al., 2014) raises the need for recognizing such variability.

A remarkable finding of the current study is simultaneous occurrence of the various variations of common carotid termination in form of quadrifurcation and pentafurcation. In general, knowledge of the quadrifurcation and pentafurcation is important to avoid inadvertent vascular injury during radical neck dissection, carotid endarterectomy, misinterpretation of head and neck angiograms especially double subtraction angiography; Super selective intra-arterial administration of chemotherapeutic agents and individual vessel catheterization (Gluncic et al., 2001; Furukawa, 2012; Vatsala, 2014); vascular surgical procedures such as carotid endoplasty for treatment of carotid stenosis (Brown et al., 1990; Dillon et al., 1993) or extracranial – intracranaial arterial by – pass for treatment of patients with occlusive cerebrovascular disease, skull base tumors and aneurysms (Gratzl et al., 1976)

Notably, all three variant terminations involved superior thyroid artery arising from the carotid bifurcation, giving this variant origin of STA a frequency of 38.5% in the black Kenyan population. This is concordant with reports that upto 49% of STA may arise from the bifurcation (Vasquez et al., 2009; Gupta et al., 2014; Joshi et al., 2014). Surgeons should be aware of such variations to minimize vascular injury and postoperative complications during thyroid surgery (Ozgur et al., 2009).

In conclusion, the black Kenyan population has over 38% frequency of variant termination of common carotid artery, comprising trifurcation, quadrifurctaion and pentafurcation, which may complicate radical neck and vascular surgery, carotid angiography and selective catheterization. Surgeons and radiologists should approach the common carotid bifurcation with extra caution.

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CONFLICT OF INTEREST: None

REFERENCES

1. Adachi B, Hasebe K 1928. Der Arterien system der Japaner. Vol 1. Kyoto, maruzen, Kaiserhck Japanaischen: Universitat Zu Kyoto: 43 – 46.
2. Al – Rafiah A, El – Haggary AA, Aal IHA, Zaki AI. 2011. Anatomical study of the carotid bifurcation and origin variations of the ascending pharyngeal and superior thyroid arteries. Folia Morphol 70: 37 – 55.
3. Ambali M, Jadhav SJ. 2012. Variations in bifurcation point and branching pattern of common carotid arteries: A cadaveric study. J Pharm Biomed Sci 25: 147 – 151.

4. Anil A, Turgut HB, Peker T, Pelin C. 2000. Variation of the branches of external carotid artery. Gazi Med J 11: 81 – 83.
5. Aswani J, Baidoo K, Otiti J 2013. Establishing a head and neck unit in developing country. J Laryngol Otol 126: 552 – 556.
6. Basekim CC, Silit E, Mutlu H, Pekkafali Z, Ozturk E, Kizikaya E.2004. Type 1 pro-atlantal artery with bilateral absence of external carotid arteries. Am J Neuroradiol 25: 1619 – 1621.
7. Brown MM, Buttler P, Gibbs J, Swash M, Waterson J. 1990. Feasibility of percutaneous transluminal angioplasty for carotid artery stenosis. J Neurol Neurosurg Psychiatr 53: 238 – 243.
8. Cavalcanti LM, Cruz CB, Guedes AJ, Andrade G, Abath CG, Fernandes RA. 2008. Importance of preoperative embolization for the treatment of the carotid body tumor: case report and review of literature. J Vasc Bras 7: 163 – 166.
9. Chitra R. 2008. Trifurcation of the right common carotid artery. Indian J Plast Surg, 41: 85 – 88.
10. Dillon EH, Van Leeuwen MS, Fernandez MA, Eikelboom BC, Mali WPTM. 1993. CT angiography application to the evaluation of carotid artery stenosis. Radiology 189: 211 – 219.
11. Dungan DH, Heiserman JE. 1996. The carotid artery: embroyology, normal anatomy and physiology. Neuroimaging Clin N Am 6: 789 – 799.
12. Furukawa S, Wingenfeld L, Takaya A, Nakagawa T, Sakaguchi I, Nishi K. 2012. Morphological variation of the carotid bifurcation level. 1: 135.doi:4172/scientificreports.135.
13. Gluncic V, Pentajek Z, Maruisic 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.
14. Gratzl O, Schmiedek P, Speltzler R, Steinhoff H, Marguth F. 1976. Clinical experience with extracranial arterial anastomosis in 65 cases. J Neurosurg 44: 313 – 324.
15. Gupta P, Bhalla AS, Thulkar S, Kumar A, Mohanti BK, Thakar A, Sharma A. 2014. Variations in superior thyroid artery. A selective angiographic study. Indian J Rad Imag 24: 66 – 71.
16. Gurbuz J, Cardar S, Ozdogmuz O. 2001. Trifurcation of the left common carotid artery – A case report. Clin Anat, 14: 58 – 61.
17. Hayashi N, Hori E, Ohtani O, Kuwayama N, Endo S. 2005. Surgical anatomy of the cervical carotid endarterectomy. Neurol Med Clir (Tokyo) 45: 25 – 29.
18. Iwai T, Izumi T, Inalle T, Fuwa N, Shibasaki M, Oguri S, Mitsudo K, Tohnai I. 2013. Thyrolinguofacial trunk arising from the carotid bifurcation determined by
19. three-dimensional computed tomography angiography. Surg Rad Anat 35: 75 – 78.
20. Jadhav SD, Ambali MP, Patil RJ, Roy PP. 2011. Thyrolingual trunk arising from common carotid bifurcation. Singarpore Med J 52: e265 – e266.
21. Joshi A, Gupta S, Variya VH. 2014. Anatomical variation in the origin of superior thyroid artery and its relation with external laryngeal nerve. Nat J Med Res 4: 138 – 141.
22. Kishve PS, Kishve SP, Joshi M, Arif SMM, Kalakoti P. 2011. An unusual branching pattern of common and external carotid artery in a human cadaver. Australas Med J 4: 180 – 182.
23. Lie TA. 1968. Congenital anomalies of the carotid arteries: Angiographic study and review of literature. Amsterdam: Excerpta Medica Foundation 30 – 35.

24. Lucev N, Bobibac D, Maric I, Drescik I. 2000. Variations of the great arteries in the carotid triangle. Otolaryngol Head Neck Surg 122: 590 – 591.
25. Marques SR, Itezerote AM, Sariolo ZD, Deangilis MA, Prates JC 2002. Anatomical variations of occipital artery: Report of two cases. Rev Chil Anat; 20: 193 – 196.
26. Nakaoka T, Matsuura H. 2002. Unilateral absence of external carotid artery: Three case reports. No Shinkei Geka 30: 1337 – 1342.
27. Natsis K, Raikos A, Foundos I, Noussois 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.
28. Ogeng'o JA, Misiani MK, Olabu BO, Waisiko BM, Murunga A. 2014. Variant termination of the left coronary artery : pentafurcation is not uncommon. Eur J Anat 18: 98 – 101.
29. Ogeng'o JA, Olabu BO, Obimbo MM, Sinkeet SR, Inyimili MI. 2012. Variant termination of basilar artery in a black Kenyan population. J Morphol Sci 29: 91 – 93.
30. Oladapo OO, Olusakin J, Ogun GO, Akang E 2013. Atherosclerosis of the intracranial carotid arteries in Nigerians. A pilot autopsy study. Nig J Cardiol 10: 62 – 67.
31. 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.
32. 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.
33. Patel PV, Patil AM, Apte AV, Attarde VY. 2014. Anomalous origin of left vertebral artery from carotid bulb seen as "trifurcation" of left common carotid artery with acute infarct in ipsilateral thalamus: A case report. J Neuro Imaging doi: 10.111/jon -12172.
34. Standring S. 2008. Gray's Anatomy. The anatomical basis of clinical practice. 40 th Edition. Spain: Churchill Livingstone, Elsevier. Pp 1380.
35. Sugavasi R, Sujatha M, Indira DB, Sirisha B, Kanchana L. 2012. Variant origin of thyrolinguo-facial trunk from left common carotid artery – A case report. Int J Health Sci Res 2: 92 – 95.
36. Tokugawa J, Nakao Y, Kudo K, Iimura K, Esaki T, Yamamoto T, Mori K. 2014. Posterior auricular artery – middle cerebral artery by pass: a rare superficial temporal artery variant with well developed posterior auricular artery – Case Report. Neurol Med Clin 54: 841 – 844.
37. Toni R, Della Casa C, Castorina S, Malaquti 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.
38. Umeoka K, Mizunari T, Murai Y, Koyabashi S, Moita A. 2014. Occlusion of the ascending pharyngeal artery during carotid artery surgery: Importance and technique Turk Neurosurg 24: 546 – 548.
39. Vasquez T, Cobiella R, Maramillo E, Vaderramina FJ, McHanwell S, Parkin I, Sanudo JR. 2009. Anatomical variation of the superior thyroid and superior laryngeal arteries. Head and Neck 31: 1078 – 1085.
40. Vatsala AR, Ajay KT, Mavishettar GF, Sangam. 2014. A study of anatomical variations of the common carotid arteries: A cadaveric study. Int J Anat Res 2: 262 – 265.