Review Article

CLINICAL BASIS FOR THE KNOWLEDGE OF ANATOMY OF THE CAROTID ARTERY: A REVIEW ARTICLE

Kpuduwei SPK[1,2,3]

[1]Department of Surgery, Federal Medical Centre, Yenagoa, Bayelsa state, Nigeria.

[2]Department of Human Anatomy, Niger Delta University, Wilberforce Island, Bayelsa state, Nigeria.

[3]Neurosurgery Division, Department of Surgery, National Hospital, Abuja, Nigeria.

Correspondence: Dr. Kpuduwei, Selekeowei Peter Kespi; +234 803 538 2152; dr.kpuduwei@gmail.com

Abstract

The carotid artery is a major artery that supplies the head and neck region. Its internal carotid branch supplies the brain directly and serves as a major vessel of interest to neurosurgeons, while the external carotid branch mainly supplies structures in the neck, scalp and face.

Whereas, diseases like atherosclerosis and aneurysm of the extracranial or intracranial parts respectively appear to affect the wall, they also have significant effect on luminal diameter and subsequent blood flow to the end organs like the brain.

The aim of this review is to remind us of the importance of the anatomical knowledge of the vessel in clinical practice. Articles from google data base and standard texts of recent publication were reviewed. The physicians and surgeons managing patients with related conditions of the carotid artery and its branches will benefit from this review.

Keywords: Common carotid artery, Internal carotid artery, External carotid artery, Brain, Anatomy, Clinical practice, Knowledge, Neurosurgery.

Cite this article: Kpuduwei SPK. Clinical basis for the knowledge of anatomy of the carotid artery: A review article. Yen Med J. 2020;2(3):23–28.

INTRODUCTION

Supply of oxygenated blood to the head and neck region of the body is majorly by the carotid artery[1] which also serves as major gateway for interventions relating to intracranial vasculature.[2] The vertebral artery via the basilar artery joins the branches of the internal carotid artery in the cranium to form the circle of Willis.[3,4] Despite the autoregulation, cerebral blood flow or perfusion pressure still depend partly on the size and capacity of the internal carotid artery and its branches.[4,5] This is in addition to cardiac output, blood pressure and cardiovascular status despite the clinical state of the individual.[6,7] Interestingly, the carotid artery is also known to suffer several structural and functional disease conditions, that affect its capacity to supply blood for the effectual perfusion of the brain.[8]

AIM

The aim of this article is to appraise the anatomy of the carotid artery and the importance of its knowledge in clinical practice with regards to radiology, vascular and neurological surgery.

MATERIALS AND METHODS

Review of articles by Woldeyes, Noh & Kang, Choudhry et al, Spasojević et al, Tolezani et al, Onaizah et al, Al-Rafiah et al, Koskinen et al, McKenna et al, Saba et al, Manterola et al, Yazici, Krejza et al, Eigenbrodt et al, Tahmasebpour et al and others on google scholar and recently published standard texts on anatomy of the carotid artery.

GROSS ANATOMY

On either side of the neck, the common and internal carotid arteries are found within the carotid sheath of the deep cervical fascia, accompanied by the internal jugular vein laterally and the vagus nerve posteriorly.[9,10] See Figures 1, 2 & 3. The right common carotid is shorter and has only a cervical part, whereas the left common carotid artery is longer with cervical and thoracic parts, as the former originates from the

brachiocephalic trunk behind the left sternoclavicular joint, whereas, the latter comes directly from the arch of the aorta in the superior mediastinum.

In the middle and upper neck, the arteries are separated by the trachea in the lower neck and thyroid gland, larynx and pharynx.[11] All major arteries arise from the aortic arch as a rule. In the classical presentation, which is about 70%), there are usually three (3) vessels: the brachiocephalic trunk on the right, the left common carotid and left subclavian artery on the left. However, there are noted several variations to this classical presentation, one of which is when the brachiocephalic trunk and left common carotid share common origin (up to 13% generally), which are more common among blacks (25%), which investigators must know. In addition to that, even the level of bifurcation of the common carotid has variations other than the classical point of C3-4 within the carotid triangle.[10,11,12] An easy way of remembering it is "bi4cation at C-4".

Surface Markings

Common carotid artery: This is represented by a vertical line extending from the sternoclavicular joint to a level at the upper border of the thyroid cartilage, where it is expected to bifurcate. The carotid pulse can be felt by pressing against the anterior tubercle of the transverse process of C6 vertebra medially between the trachea and lower larynx medially or laterally on the sternocleidomastoid muscle at the same level (carotid tubercle of Chassaignac).[9]

External carotid artery: This is represented by a vertical line extending from the common carotid artery bifurcation (mostly at C-4 level) moving up behind the angle of the mandible to a point immediately in front of the tragus of the ear.[9]

Internal carotid artery: In the cervical region along a line from the common carotid artery bifurcation to the head of the mandible.[9]

This knowledge is important to avoid complications when siting central venous lines via the jugular vein, which adjacent to the common carotid artery in the root of the neck, as some clinicians have had terrible experiences following inadvertent cannulation of the carotid artery.

Branches of the internal and external carotid arteries

The external carotid artery gives eight branches in the cervical region to supply organs and body parts in the neck, face and scalp. The branches are superior thyroid, ascending pharyngeal, lingual, facial, occipital, posterior auricular, superficial temporal and maxillary arteries.[9,13,14] The internal carotid artery does not give any branch in the cervical region until it enters the cranium.

In neurosurgical practice, the internal carotid artery is divided into seven segments, namely the cervical, petrous, lacerum, cavernous, clinoid, ophthalmic and communicating segments according to the intracranial course of the artery. The artery, after giving several branches intracranially, ends as the anterior cerebral and middle cerebral arteries.[14] The internal carotid artery also gives major contribution in the formation Circle of Willis, an arterial anastomosis that supplies blood to the brain.[14,4]

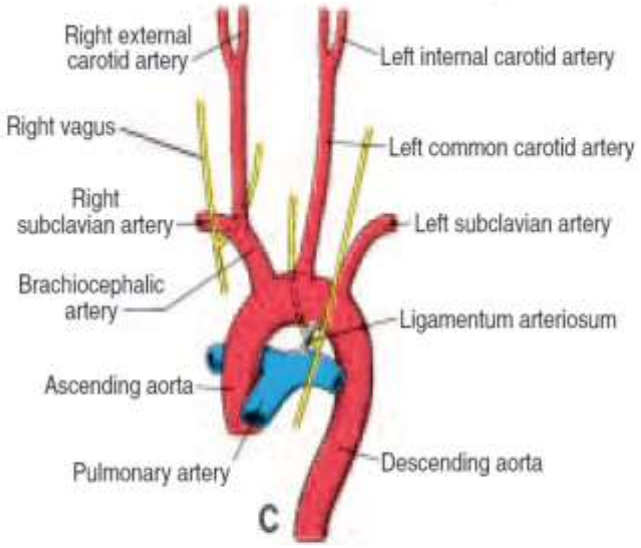

Figure 1: The great arteries in the adult. Source: Longman's Medical Embryology: Cardiovascular System. 9th ed.[15]

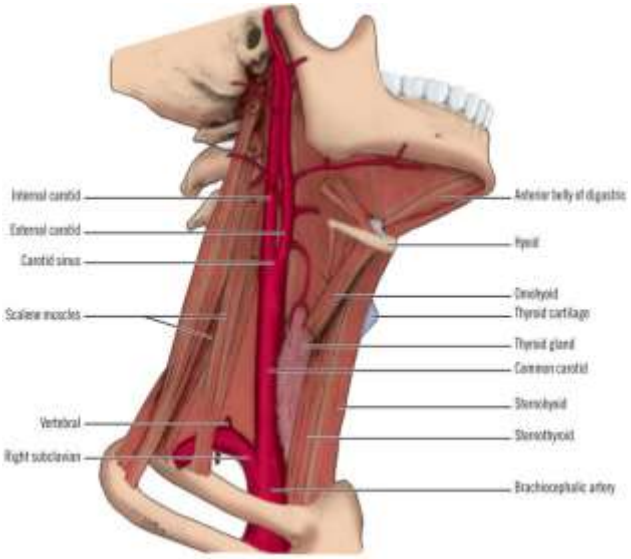

Figure 2: Common carotid artery and internal and external carotid arteries. Source: Skandalakis Surgical Anatomy.[16]

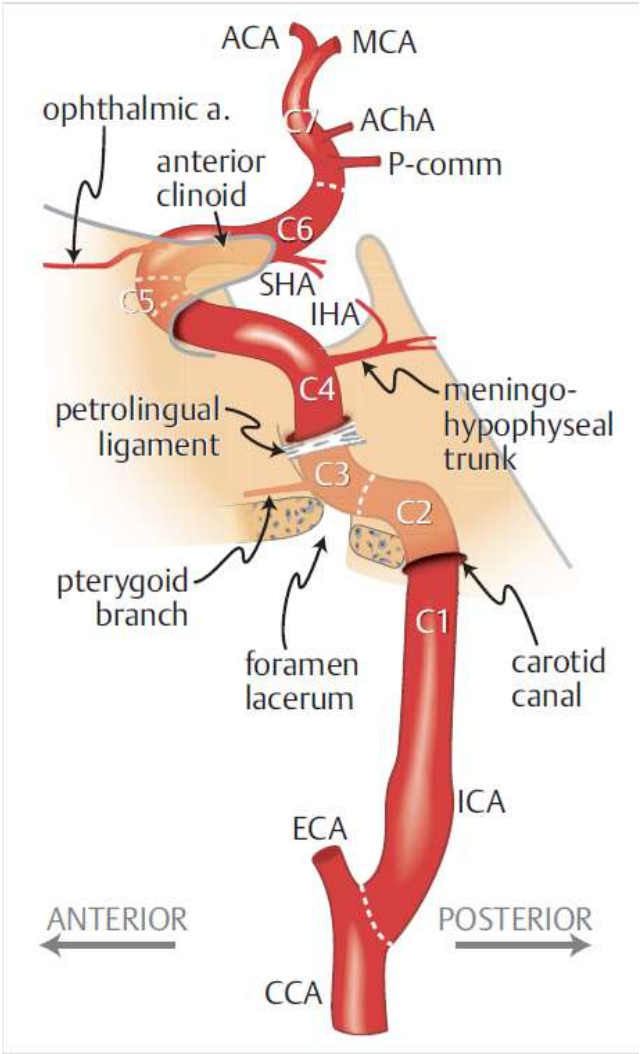

Figure.3: Segments of the internal carotid artery. Source: Handbook of Neurosurgery. 9th ed.[14]

Key: Left ICA viewed from the left side. Abbreviations: ACA = anterior cerebral artery; AChA = anterior choroidal artery; CCA =common carotid artery; ECA = external carotid artery; IHA = inferior hypophyseal artery; MCA= middle cerebral artery; P-comm= posterior communicating artery; SHA = superior hypophyseal artery

RADIOLOGIC EVALUATION OF THE CAROTID ARTERY

The carotid artery like other arteries of the body have been studied using several radiological methods. These methods afford the clinician a picture of the status of the vessel of interest of the particular patient.[17] The radiological modalities for the carotid artery can be conventional angiography, CT angiography or MR angiography. One report cited MRI as a reliable non-invasive and cost-worthy modality for assessing and monitoring carotid artery over ultrasonography with respect to arterial stenosis.[18]

Another report has cited CT angiography as the most used for the evaluation of arterial stenosis, as it portrays the whole vascular tree of interest.[19] However, measurement of pulse wave velocity, intima-media thickness and real-time assessment of luminal diameter is more feasible with ultrasonography. Sonographic pulse wave velocity of arteries is said to be reproducible and reliable thereby making it the gold standard for assessing arterial wall stiffness, which alongside intima-media thickness and luminal diameter can be used to predict risk of cardiovascular events and prognosticate cerebrovascular disease in patients.[7,20]

Ultrasonography of carotid artery has gained wide and popular recognition among surgeons and physicians alike because of its accessibility, affordability and reliability in clinical practice. A study comparing sonographic study of the carotid artery with angiography discovered a reasonable number of discrepancies in evaluation of stenosis, using the angiography as the gold standard for judgement. The angiography was better in diagnosing stenosis generally. However, the colour Doppler image revealed the degree of stenosis of the artery better.[21] CT angiography has been used to assess bifurcation angles of carotid artery and related same to stroke in one study.[22] Although, the angiographic studies have some advantages (like studying entire vascular tree for luminal stenosis, aneurysms, etc.) but it cannot measure

arterial wall thickness or real-time luminal diameter, when the ultrasound scan can measure both the arterial lumen diameter and wall thickness.[23]

Ultrasound of carotid artery

Ultrasound has a wide and acceptable usage. And common indications for the use of ultrasound scan in examining extracranial carotid and vertebral arteries in clinical practice include but are not limited to evaluation of patients with stroke or suspected to be at risk, preoperative evaluation of patients going for vascular procedures, patients with syncopal syndromes, intraoperative monitoring of patients undergoing vascular surgery, patients with pulsating neck masses, patients with neck trauma, follow up of patients with proven carotid disease, etc.[24] Neurosurgeons, vascular surgeons and neurovascular radiologists have often relied on the findings of the carotid ultrasound scans to make diagnoses and follow up patients post-operatively.[25]

The procedure is carried out by radiologists, vascular scientists and medical physicists alike.[26] Duplex scan has remained the preferred method of investigation to some clinicians because it is the cheapest, most affordable and available diagnostic modality that provides real-time data of the carotid artery,[27] as well as being highly sensitive, specific and accurate in detecting carotid artery lesions.[27] It is also reliable and valid mode of investigation for the carotid artery because it is reproducible under experienced hands.[23] It gives room for easy study and follow up, because it does not require special preparations unlike angiographies.[28] It can also be mobile making it easy for bedside studies and diagnosis for patients that cannot ambulated.[29] More importantly, it is a non-invasive mode of investigation making it a more preferable choice to angiographies.[30] And that is why ultrasound is the primary recommended investigative modality for the extracranial carotid artery in clinical practice.

PATHOLOGIES OF THE CAROTID ARTERY

Diseases of the carotid artery include but are not limited to atherosclerosis, luminal stenosis, wall stiffness affect its effective diameter, elasticity, and the velocity and volume of blood supplied to the brain[1]. Studies have shown that carotid artery lumen diameter, wall thickness (intima-media thickness) can impact on blood flow velocity and perfusion pressure to the brain[31] and in the same vein, can be influenced by body size, neck size, sex, and certain clinical and laboratory parameters.[32]

The luminal diameter and intima-media thickness can also be used to predict the risk of cerebrovascular events in patients.[30,27,23,33] There is a direct relation of atherosclerosis of the carotid artery with stroke.[34] It has been established that these associations can further be influenced by ethnicity or race.[19] From embryological point of view, vessels have wide range of variations, and the carotid artery is one with several known variations.[12,10]

It is also an established clinical fact that patients with severe carotid artery stenosis discovered on ultrasound scan may require endarterectomy to remove atherosclerotic plagues to increase luminal diameter for improved blood flow and supply to the brain.[25] This is because of the risk of total arterial occlusion or the attendant cerebrovascular events like thromboembolism and stroke in such patients.[8,35]

Vascular aneurysms are potentially life-threatening conditions, especially when they rupture. Vascular aneurysms of the anterior circulation of the brain, which occur in branches of the internal carotid artery are very common in neurosurgical practice. All these and other vascular diseases affect the carotid artery, especially with advancing age, thereby making it an organ of significant clinical importance.[36,37]

The clinical evaluation of the anatomy of the carotid artery is also important in preparation for vascular or neurovascular interventions like endarterectomy, stenting, aneurysmal clipping,[38] as the carotid artery is the major gateway for such major intracranial neurovascular interventions.[2] Therefore, the knowledge of its anatomy is crucial for the procedure.

CONCLUSION

The carotid artery serving as a major blood supply to the brain plays vital role in the cerebral perfusion and metabolism in the head and neck region. Because diseases of the vessel and its branches could manifest as either life modifying or life-threatening conditions, it is a vessel of interest to clinicians, both physicians and surgeons alike. Therefore, knowledge of its anatomy is crucial in clinical practice in the related specialties.

REFERENCES

1. Woldeyes DH. Anatomical Variations of the Common Carotid Artery Bifurcations in Relation to the Cervical Vertebrae in Ethiopia. Anat Physiol Curr Res. 2014;4(3):1–3.
2. Choudhry FA, Grantham JT, Rai AT, Hogg JP. Vascular geometry of the extracranial carotid arteries: an analysis of length, diameter, and tortuosity. J NeuroIntervent Surg. 2015;0:1–5.
3. Spasojević G, Vujmilović S, Vujković Z, Gajanin R, Malobabić S, Ponorac N, et al. Internal carotid and vertebral arteries diameters and their interrelationships to sex and left/right side. Folia Morphol. 2020;79(2):219–25.
4. Greene NH, Lee LA. Modern and Evolving Understanding of Cerebral Perfusion and Autoregulation. Adv Anesth. 2012;30(1):97–129.
5. Silverman A. Physiology, Cerebral Autoregulation. https://www.statpearls.com/kb/viewarticle/83781/. 2020. Accessed May 7, 2020.
6. Meng L, Hou W, Chui J, Han R, Gelb AW. Cardiac Output and Cerebral Blood Flow: The Integrated Regulation of Brain Perfusion in Adult Humans. Anesthesiology. 2015;123:1198–1208.
7. Tolezani EC, Costa-Hong V, Correia G, Mansur AJ, Drager LF, Bortolotto LA. Determinants of Functional and Structural Properties of Large Arteries in Healthy Individuals. Arq Bras Cardiol. 2014;103(5):426–432.
8. Onaizah O, Poepping T, Zamir M. Model of blood supply to the brain via the carotid arteries: Effects of obstructive vs. sclerotic changes. Med Eng Phys. 2017;49:121–130.
9. Sinnatamby CS. Last's Anatomy: Regional and Applied. 12th ed. UK: Churchill Livingstone; 2011.
10. Sheikh-Bahaei N, Matys T, Gillard JH. Anatomy of the Neck Arteries. In: Saba L Raz E, eds. Neurovascular Imaging. New York: Springerlink; 2016:87–94.
11. Standring S. Neck. In: Gray's Anatomy: The Anatomical basis of Clinical practice. 39th ed. UK: Churchill Livingstone; 2008:543–544.
12. Al-Rafiah A, EL-Haggagy AA, Aal IH, Zaki AI. Anatomical study of the carotid bifurcation and origin variations of the ascending pharyngeal and superior thyroid arteries. Folia Morphol. 2011;70(1):47-55.
13. Lasjaunias PL. The External Carotid Artery: Functional Anatomy. Riv di Neuroradiol. 1991;4(Suppl. 1):39–45.
14. Greenberg MS. Handbook of Neurosurgery. 9th ed. New York: Thieme Medical Publishers Inc; 2020:82–86.
15. Sadler TW. Cardiovascular System. In: Longman's medical Embryology. 9th ed. Philadelphia: Lippincott Williams & Wilkins; 2010:255–258.
16. Skandalakis JE, Colborn GL, Weidman TA, Foster Jr RS, Kingsnorth AN, Skandalakis LJ, et al. Skandalakis Surgical Anatomy. 2006.
17. Oddone EZ, Horner RD, Sloane R, McIntyre L, Ward A, Whittle J, et al. Race, Presenting Signs and Symptoms, Use of Carotid Artery Imaging and Appropriateness of Carotid Endarterectomy. Stroke. 1999; 30(7):1350–1356.
18. Creagh S, Ortiz A, Fumero J, Paydar A. Impact of MRI Characterization of the Carotid Artery in the Understanding of Stroke. Omi J Radiol. 2017;6(2):1–5.
19. Koskinen SM, Soinne L, Valanne L, Silvennoinen H. The normal internal carotid artery: a CTA study. Neuroradiology. 2014;56(9):723–729.
20. Alastruey J. Numerical assessment of time-domain methods for the estimation of local arterial pulse wave speed. J Biomech. 2010;44(2011):885–891.
21. Horrow MM, Stassi J, Shurman A, Brody JD, Kirby CL, Rosenberg HK. The Limitations of Carotid Sonography: Interpretive and Technology-Related Errors. Americ J Roentgenol. 2000;174:189–194.
22. Noh SM, Kang HG. Clinical significance of the internal carotid artery angle in ischemic stroke. Sci Rep. 2019;9(4618):1–5.
23. Rashid SA, Mahmud SA. Correlation between Carotid Artery Intima-Media Thickness and Luminal Diameter with Body Mass Index and Other Cardiovascular Risk Factors in Adults. Sultan Qaboos Univ Med J. 2015;15(3):e344–e350.
24. AIUM Practice Parameter for the Performance of an Ultrasound Examination of the Extracranial Cerebrovascular System. J Ultrasound Med. 2016;35(9):1-11. doi:10.7863/ultra.35.9.1.
25. Tahmasebpour HR, Buckley AR, Cooperberg PL, Fix CH. Sonographic Examination of the Carotid Arteries. RadioGraphics. 2005;25(6):1561–1575.
26. McKenna MA, Bonfield MC, Robinson T. Levels

of agreement in the measurements of carotid artery ultrasound across a regional vascular network. Ultrasound. 2018;26(2):101–109.

27. Saba L, Banchhorb SK, Arakic T, Viskovicd K, Londheb ND, Lairde JR, et al. Intra- and inter-operator reproducibility of automated cloud-based carotid lumen diameter ultrasound measurement. Indian Hear J. 2018;1394:19.

28. Wikstrand J. Methodological considerations of ultrasound measurement of carotid artery intima–media thickness and lumen diameter. Clin Physiol Funct Imaging. 2007; 27(6):341–345.

29. Hilbert T, Klaschik S, Ellerkmann RK, Putensen C, Thudium M. Common carotid artery diameter responds to intravenous volume expansion: an ultrasound observation. Springerplus. 2016;5(853):1-6.

30. Manterola HL, Vercio LL, Díaz A, Fresno MD, Larrabid I. Validation Of An Open-Source Tool For Measuring Carotid Lumen Diameter And Intima–Media Thickness. Ultrasound Med Biol. 2018;44(8):1873–1881.

31. Yazici B, Erdoğmuş B, Tugay A. Cerebral blood flow measurements of the extracranial carotid and vertebral arteries with Doppler ultrasonography in healthy adults. Diagn Interv Radiol. 2005;11:195-198.

32. Krejza J, Arkuszewski M, Kasner S, Weigele J, Ustymowicz A, Hurst RW, et al. Carotid Artery Diameter in Men and Women and the Relation to Body and Neck Size. Stroke. 2006;37:1103–1105.

33. Eigenbrodt ML, Sukhija R, Rose KM, Tracy RE, Couper DJ, Evans GW, et al. Common carotid artery wall thickness and external diameter as predictors of prevalent and incident cardiac events in a large population study. Cardiovasc Ultrasound. 2007;5(11):1-11.

34. Carotid Artery Disease. Mayo Clinic.

https://www.mayoclinic.org/diseases-conditions/carotid-artery-disease/symptoms-causes/syc-20360519. 2018. Accessed May 4, 2020.

35. Ogungbo B, Ogun SA, Ushewokunze S, Mendelow A, Rodgers H, Walker R. How Can We Improve The Management Of Stroke In Nigeria, Africa? Afri J Neurol Sci. 2005;24(2):e.

https://ajns.paans.org/how-can-we-improve-the-management-of-stroke-in-nigeria-africa/ Accessed May 4, 2020.

36. Bit A, Ghagare D, Rizvanov AA, Chattopadhyay H. Assessment of Influences of Stenoses in Right Carotid Artery on Left Carotid Artery Using Wall Stress Marker. BioMed Res Int'l. 1:1–13.

37. Johnsen SH, Joakimsen O, Singh K, Stensland E, Forsdahl SH, Jacobsen BK. Relation of Common Carotid Artery Lumen Diameter to General Arterial Dilating Diathesis and Abdominal Aortic Aneurysms: The Tromsø Study. Americ J Epidemiol. 2008;169(3):330–338.

38. Jackson AE. Carotid Artery Aneurysm. J Vasc Ultrasound. 2017;41(1):13–17.