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Review Article

Occipital artery: Anatomical variations and neurosurgical applications

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ABSTRACT

Background: The occipital artery (OA) is a branch of the external carotid artery. It gives rise to several cutaneous, muscular, and meningeal branches to supply different anatomical areas. The implication of OA in the neurosurgical field is well-established in the literature. Our aim in this study is to draw a complete picture of the anatomical variations and neurosurgical applications of the OA.

Methods: A literature review was conducted in Google Scholar and PubMed to review the studies discussing OA, its anatomical variation, and neurosurgical applications.

Results: We identified 29 articles that discuss the anatomical variations and neurosurgical applications of the OA. Certain variables are used to describe the surgical anatomy of OA. We also discussed certain applications of OA and its importance in neurosurgical bypass, embolization, and aneurysms.

Conclusion: Comprehending the anatomy of the OA is crucial for neurosurgeons to safely and effectively perform procedures such as bypass and embolization. In addition, knowledge of the anatomical variations of the OA can help surgeons anticipate potential challenges and tailor their approach accordingly.

Keywords: Anatomical variations, Bypass, Neuroanatomy, Occipital artery

INTRODUCTION

The occipital artery (OA) originates from the posterior part of the external carotid artery (ECA).[6] Several cutaneous, muscular, and meningeal branches emerge from it to subsequently nourish various anatomical areas. Detailed knowledge of the anatomy of the OA and its branches is of utmost importance to avoid potential disastrous complications during therapeutic embolization of neoplastic or vascular processes fed by this vessel.[1]

The neurosurgical importance of OA arises from its role in the bypass. The OA gives bypass to the posterior inferior cerebellar artery (PICA), anterior inferior cerebellar artery (AICA), posterior cerebral artery (PCA), and middle cerebral artery (MCA).[2]

The implication of OA in the neurosurgical field is well-established in the literature. However, we were unable to find studies that provide a collective and cumulative description of the anatomy and clinical applications of OA. Our aim in this study is to draw a complete picture of the anatomical variations and neurosurgical applications of the OA.

MATERIALS AND METHODS

A literature review was conducted in Google Scholar and PubMed to review the studies discussing OA, its anatomical variation, and neurosurgical applications. The following search terms were used: "occipital artery vascular anatomy" and "occipital artery neurosurgical applications." Inclusion criteria were as follows: (i) English language and (ii) suitable methodology of the targeted data. We exclude studies with the following criteria (i) non-English papers and (ii) questionable results. Results were categorized and selected appropriately. The data extraction includes surgical anatomy and neurosurgical applications of the OA.

RESULTS

On reading and reviewing the available articles and original works regarding OA, concerning the inclusion and exclusion criteria, we identified 29 articles that discuss the anatomical variations and neurosurgical applications of the OA. Certain variables are used to describe the surgical anatomy of OA including origin, course, branches, diameter, and length. We also discussed certain applications of OA and its importance in neurosurgical bypass, embolization, and aneurysms.

DISCUSSION

OA anatomy

OA origin

The OA is a branch of the ECA. It normally originates from the posterior aspect of the ECA opposite to the facial artery. Recent evidence also reflects that OA may infrequently originate from the internal carotid artery (ICA) while OA that originates from the vertebral artery is a highly rare phenomenon.[6] The origin of the OA was detected in carotid arteries (97%) while the incidence of it arising from the ICA was 0.2%.[11]

OA course

The initial segment of OA is straight as it travels up through the upper neck, then the vessel becomes more torturous and provides a more redundant blood supply as it travels up the posterior scalp.[1]

The OA has three segments based on the vertical muscle layers through which they run; subcutaneous, transitional, and intramuscular. OA courses 81.9 mm from the digastric groove as it exists to the superior nuchal line, then it travels superiorly and posteriorly, passing superficially to the ICA and the vagus nerve, before anastomosing with the deep cervical artery as it courses just beneath the mastoid process of the temporal bone. It, then, travels deep to the sternocleidomastoid and splenius capitis muscles until it reaches the occipital bone's superior nuchal line, where it then travels superficially to the semispinalis capitis muscle. After it has coursed about halfway across the semispinalis capitis and just lateral of the trapezius, the artery then courses vertically up the back of the head superficial to the occipital belly of the occipitofrontalis. It ascends tortuously up the head in the superficial fascia, anastomosing with a branch of the posterior auricular artery. Then, at the crown of the head, it anastomoses with the parietal branch of the superficial temporal artery.[24]

OA branches

The OA gives cutaneous branches that supply the occipital area. In addition, it gives rise to several other branches, including the auricular, mastoid, descending, meningeal, muscular, and sternocleidomastoid branches [Figure 1]. The auricular branch supplies the area behind the ear, and the mastoid branch supplies the mastoid air cells, diploe, and dura mater.

The descending branch is the largest division and contains a deep and superficial portion. The superficial portion provides blood to the trapezius, and the deep portion anastomoses with a branch of the costocervical trunk, providing collateral circulation through the ECA and the subclavian artery.

The meningeal branch supplies the posterior cranial fossa dura mater. The muscular branches supply several muscles along the course of the OA, including the digastric and

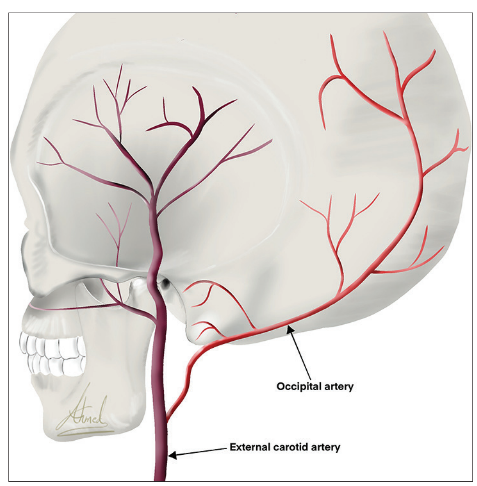

Figure 1: An artistic depiction shows the occipital artery, its course, and branches.

longus capitis muscles. The sternocleidomastoid branch divides the carotid triangle into upper and lower branches and supplies the muscle that is named after it.[10]

OA diameter and length

The mean diameter of OA as it exits from the digastric groove is about 2.05 mm, and at the level of the superior nuchal line, is approximately 2.01 mm.[9] A recent meta-analysis of the OA anatomy has found that the mean maximal diameter of the OA is 2.26 mm.[21] The same study found the mean OA length to be 131.93 mm.

Neurosurgical application of OA

Bypass

The OA is an important donor artery for posterior fossa revascularization due to its size, anatomical proximity to target recipient vessels, and flow rate. In addition, the OA has been reported to provide a mean blood flow of 15–80 mL/min when used for posterior fossa bypass.[2] The OA gives bypass to PICA, AICA, PCA, and MCA.

OA-PICA bypasses

It is the first intracranial posterior circulation revascularization procedure to treat vertebrobasilar insufficiency, as reported by Ausman *et al*.[4] and has played an important role in the cerebral revascularization of the posterior circulation.

Kawashima *et al*. conducted an anatomical study of OA-PICA bypasses, which showed several advantages: (1) The recipient vessel, which is usually the caudal loop of the PICA, has a rather large diameter, thus making the anastomosis easier. (2) The lumen caliber of the donor vessel, which is usually the OA, closely approximates that of the recipient vessel. (3) The bypass surgery can be performed in a shallow and wide operative field, which makes the procedure easier.[13]

The caudal loop of the PICA which is a portion of the tonsillomedullary segment is generally considered to be the optimal site for OA-PICA anastomosis, and its inferomedial location facilitates anastomosis with adequate intraoperative maneuverability and only minimal retraction of the cerebellar tonsil.[16-26]

Lister *et al*. described two anatomical variants of PICA with absent caudal loops, both of which take on a straight course.[18] In patients with significant anatomical variations of the PICA, the technical difficulty of OA-PICA bypass increases due to suboptimal access to the alternative anastomosis sites, which are further complicated by the narrow and deep nature of the surgical corridor and a less favorable surgical orientation. Bypass at the lateral medullary and telovelotonsillar segments is more surgically challenging due to their increased distance from the dural surface, but they present the best alternative anastomosis sites in the absence of the caudal loop.[7]

OA-PCA bypass

OA-PCA bypass is used as an alternative to conventional superficial temporal artery-superior cerebellar artery bypass or in the event that PCA bypasses are unavailable. A few cases of OA-PCA interposition graft bypass through the occipital interhemispheric approach have been reported for vertebral artery occlusion and PCA aneurysms.[17-28]

OA-MCA bypass

OA-MCA bypass is a less commonly used procedure; however, it can be effective when the posterior region of the brain requires an additional source of blood supply, and this bypass is preferred in the lateral position, with the head slightly rotated toward the contralateral side to expose the surgical region, which helps to decrease the risk of high intracranial pressure and brain bulging.[14]

In addition, it could be beneficial to obtain a large craniotomy and to combine the OA-MCA bypass with indirect revascularization procedures such as encephaloduroarteriosynangiosis or pericranial flap; therefore, OA-MCA bypass has been implicated in the treatment of moyamoya disease.[23] It is regarded as a direct bypass technique where extracranial-intracranial arterial anastomosis is performed. The disadvantage of this procedure is delayed wound healing after anterior circulation revascularization because harvesting the OA will reduce the blood supply in the scalp.[14]

OA-AICA bypass

This anastomosis is rarely performed because the AICA is too thin, causing it to be mismatched with the OA.[27] Despite the difficulty, an OA-AICA bypass can be performed. For instance, in 2012, Fujimura *et al*. treated a ruptured intrameatal AICA aneurysm, and OA-AICA anastomosis with aneurysm trapping was performed.[8] It is important to dissect a sufficiently long piece of the OA to be able to reach the AICA at the petrous surface, as the dissection may need to extend to the level of the mastoid process.[3]

OA embolization

Therapeutic embolization of the ECA or its branches is widely accepted as a definitive treatment or an adjunct surgical procedure in patients with highly vascular craniofacial lesions.[5] A case report from Mohit *et al*. revealed an aneurysmal bone cyst treated by arterial embolization; one of the feeding arteries of this cyst is the OA.[20] Another report describes a unique instance of carotid-cavernous sinus fistula supplied solely by ECA with an unusual and previously undescribed contribution from the OA, treated by arterial embolization.[19]

This procedure is generally considered to be safe and without risks, although complications such as facial palsy, intracranial stroke, and tissue necrosis may occur.[5] Extra- to intracranial arterial anastomoses between the occipital and vertebral arteries are also reported.[5,25] Kerber has previously reported such an anastomosis while embolizing a scalp arteriovenous malformation. He suggested that the mechanism is related to increased intraluminal pressures from the injection, forcing open an extra-to intracranial anastomosis.[15]

OA aneurysm

The true aneurysms are caused by a defect in the wall of the vessels. In contrast, pseudoaneurysms, which are also known as false aneurysms, are the result of a vessel wall rupture, often secondary to trauma.[12] OA aneurysms occurred slightly more often in men (59%). The left OA has been more commonly affected (59%). All reported OA pseudoaneurysms were the result of trauma. Mechanisms of trauma included falls, assault with a bottle and belt, basketball, football, and high-velocity paintball missiles.[22-29]

CONCLUSION

Being acquainted with the variable anatomy of the OA is crucial for successful neurosurgical bypass, embolization, and various treatment modalities of aneurysms. The need for more cadaver research may help neurosurgeons gain a more comprehensive understanding of the OA's anatomy and its variations. This can provide valuable insights into the optimal placement and trajectory of bypass grafts, minimizing the risk of postoperative complications.

Declaration of patient consent

Patient's consent not required as there are no patients in this study.

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Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The author(s) confirms that there was no use of Artificial Intelligence (AI)-Assisted Technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

REFERENCES

1. Alvernia JE, Fraser K, Lanzino G. The occipital artery: A microanatomical study. Neurosurgery 2006;58:S114-22.
2. Ate ş O, Ahmed AS, Niemann D, Baskaya MK. The occipital artery for posterior circulation bypass: Microsurgical anatomy. Neurosurg Focus 2008;24:E9.
3. Ausman JI, Diaz FG, Vacca DF, Sadasivan B. Superficial temporal and occipital artery bypass pedicles to superior, anterior inferior, and posterior inferior cerebellar arteries for vertebrobasilar insufficiency. J Neurosurg 1990;72:554-8.
4. Ausman JI, Lee MC, Klassen AC, Seljeskog EL, Chou SN. Stroke: What's new? Cerebral revascularization. Minn Med 1976;59:223-7.
5. Bitoh S, Hasegawa H, Obashi J, Maruno M. Sudden appearance of occipital-vertebral arterial anastomoses during therapeutic embolization. Surg Neurol 1985;24:160-4.
6. Cetin N, Akkan K, Ucar M, Onal B, Ilgit E. Bilateral occipital arteries of internal carotid origin: Report of a case and review of the literature. J Belg Soc Radiol 2015;99:69-71.
7. Crowley RW, Medel R, Dumont AS. Operative nuances of an occipital artery to posterior inferior cerebellar artery bypass. Neurosurg Focus 2009;26:E19.
8. Fujimura M, Inoue T, Shimizu H, Tominaga T. Occipital artery-anterior inferior cerebellar artery bypass with microsurgical trapping for exclusively intra-meatal anterior inferior cerebellar artery aneurysm manifesting as subarachnoid haemorrhage. Case report. Neurol Med Chir (Tokyo) 2012;52:435-8.
9. Fukuda H, Evins AI, Burrell JC, Stieg PE, Bernardo A. A safe and effective technique for harvesting the occipital artery for posterior fossa bypass surgery: A cadaveric study. World Neurosurg 2014;82:e459-65.
10. Graefe S, Tadi P. Neuroanatomy. In: StatPearls. Treasure Island, FL: StatPearls Publishing; 2020.
11. Iwai T, Izumi T, Inoue T, Maegawa J, Mitsudo K, Tohnai I. Incidence of the occipital artery arising from the internal carotid artery identified by three-dimensional computed tomographic angiography. Br J Oral Maxillofac Surg 2012;50:373-5.
12. John N, Leach JL, Rachana T, Mangano FT. Traumatic aneurysm of the occipital artery secondary to paintball injury. Clin Neurol Neurosurg 2009;111:105-8.
13. Kawashima M, Rhoton AL Jr., Tanriover N, Ulm AJ, Yasuda A, Fujii K. Microsurgical anatomy of cerebral revascularization. Part II: Posterior circulation. J Neurosurg 2005;102:132-47.
14. Kazumata K, Kamiyama H, Saito H, Maruichi K, Ito M, Uchino H, *et al.* Direct anastomosis using occipital artery for additional revascularization in moyamoya disease after combined superficial temporal artery-middle cerebral artery and indirect bypass. Oper Neurosurg (Hagerstown) 2017;13:213-23.
15. Kerber CW. Flow-controlled therapeutic embolization: A physiologic and safe technique. AJR Am J Roentgenol 1980;134:557-61.
16. Khodadad G, Singh RS, Olinger CP. Possible prevention

of brain stem stroke by microvascular anastomosis in the vertebrobasilar system. Stroke 1977;8:316-21.
17. Korinth MC, Thron A, Bertalanffy H, Gilsbach JM. Coil embolization of an incidental posterior cerebral artery aneurysm after initial OA-PCA bypass surgery. Zentralbl Neurochir 2000;61:158-61.
18. Lister JR, Rhoton AL Jr., Matsushima T, Peace DA. Microsurgical anatomy of the posterior inferior cerebellar artery. Neurosurgery 1982;10:170-99.
19. Mahalley MS Jr., Boone SC. External carotid-cavernous fistula treated by arterial embolization. Case report. J Neurosurg 1974;40:110-4.
20. Mohit AA, Eskridge J, Ellenbogen R, Shaffrey CI. Aneurysmal bone cyst of the atlas: Successful treatment through selective arterial embolization: Case report. Neurosurgery 2004;55:982.
21. Ostrowski P, Bonczar M, Plutecki D, Kwiecińska M, Rams D, Dziedzic M, *et al.* The occipital artery: A meta-analysis of its anatomy with clinical correlations. Anat Sci Int 2023;98:12-21.
22. Patel M, Tchelepi H, Rice DH. Traumatic pseudoaneurysm of the occipital artery: Case report and review of the literature. Ear Nose Throat J 2008;87:E7-12.
23. Reis CV, Safavi-Abbasi S, Zabramski JM, Gusmão SN, Spetzler RF, Preul MC. The history of neurosurgical procedures for moyamoya disease. Neurosurg Focus 2006;20:E7.
24. Sakharpe AK, Caseclla M. SteatPearls. Treasure Island, FL: SteatPearls Publishing; 2021.
25. Spetzler RF, Modic M, Bonstelle C. Spontaneous opening of large occipital-vertebral artery anastomosis during embolization. Case report. J Neurosurg 1980;53:849-50.
26. Sundt TM Jr., Piepgras DG. Occipital to posterior inferior cerebellar artery bypass surgery. J Neurosurg 1978;48:916-28.
27. Touho H, Karasawa J, Ohnishi H, Nakase H, Watabe Y, Yamada K, *et al.* Anastomosis of occipital artery to anterior inferior cerebellar artery with interposition of superficial temporal artery. Case report. Surg Neurol 1993;40:164-70.
28. Touho H, Karasawa J, Ohnishi H, Kobitsu K. Anastomosis of occipital artery to posterior cerebral artery with interposition of superficial temporal artery using occipital interhemispheric transtentorial approach: Case report. Surg Neurol 1995;44:245-9.
29. Yang HJ, Choi YH. Posttraumatic pseudoaneurysm in scalp treated by direct puncture embolization using N-butyl-2-cyanoacrylate: A case report. Korean J Radiol 2005;6:37-40.

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