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Posterior auricular artery. Anatomical variations and neurosurgical applications

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ABSTRACT

Introduction: The posterior auricular artery (PAA) is the preterminal branch of the external carotid artery (ECA), arising superiorly to the occipital artery (OA). The PAA has quite a few anatomical variations and established neurosurgical applications. We conducted this study as an overview to illustrate all neurosurgical aspects regarding this artery, its reconstructive uses, and anatomical variation.

Method: We performed a literature review in Google Scholar and PubMed medical databases for studies discussing the PAA, its anatomical variations, and neurosurgical applications.

Results: We identified 30 articles that discuss the anatomical variations and neurosurgical applications of the PAA. While reviewing the available articles and original works regarding PAA.

Conclusion: The PAA has considerable anatomical variations regarding its origin, course, branches, and length. The related neurosurgical applications of PAA include bypass, embolization, aneurysm, AVM, and reconstruction flaps.

INTRODUCTION

The posterior auricular artery (PAA) is the preterminal branch of the external carotid artery (ECA), arising superiorly to the occipital artery (OA), and coursing between the mastoid process anteriorly and the external auditory meatus posteriorly, accompanying the posterior auricular nerve (16). PAA crosses the facial nerve inferior to the stylomastoid foramen and then mainly passes lateral to it. PAA gives off three to five branches supplying part of the external ear, retroauricular area, and part of the facial nerve (15), finally terminating at any point distally between its origin and the vertex (24).

The PAA has limited considerations in standard neurosurgical and neuro-radiographical textbooks (25). Therefore, we conducted this study as an overview to illustrate all neurosurgical aspects regarding this artery, its reconstructive uses, and anatomical variation.

Methods

We searched the databases Google Scholar and PubMed for articles about the PAA, its anatomical variants, and neurosurgical applications. We used the following search terms: "posterior auricular artery vascular anatomy", "posterior auricular artery neurosurgical applications". We included the studies that were written in English and had suitable methodology for the targeted data, while exclusion criteria were, i) non-English papers, ii) questionable results. Results were categorized and selected appropriately. The data extraction includes surgical anatomy and neurosurgical application of the PAA.

Results

We located 30 publications that go into the anatomical differences and neurosurgical uses of the PAA. Considering the inclusion and exclusion criteria, review the original articles and papers on PAA that are currently available. We outline the surgical anatomy of PAA, including its origin, path, branches, diameter, and length. Also covered were the uses of PAA and its significance in neurosurgical bypass and aneurysms.

Discussion

1.PAA anatomy

1.1 PAA Origin

The PAA is a posterior branch of the ECA, arising 25 mm superior to the OA between the parotid gland and stylomastoid foramen (26). PAA originates independently from ECA in most instances: in 10-15% of cases it arises with the OA as an occipito-auricular trunk. PAA could arise with the Ascending Pharyngeal Artery in 1-7% (15,30). However, some authors reported the absence of PAA in two out of ten specimens (23).

1.2 PAA Course

PAA arises lateral to the upper border of the posterior belly of the digastric muscle, ascending backward and upward along or superficial to it. At the level of the stylomastoid foramen, it runs in the auriculo-mastoid sulcus, between the mastoid process anteriorly in at a mean distance of 0.29 cm and the external auditory meatus posteriorly at a mean distance of 1.19 cm parallel to the Frankfort plane. At this point, PAA is superficial, suprafascial, and subcutaneous (16,26).

PAA's position on the anterior surface of the mastoid process is considered to be an important landmark in the surgical identification of the facial nerve in parotidectomy (3). Its location posterior to the external auditory meatus parallel to the Frankfort plane is considered to be ideally located in the posterior border of a standard craniotomy around the Sylvian point (18).

PAA continues to ascend vertically under the cranial surface of the concha, deep into the posterior auricular muscle (15). PAA terminates in the temporoparietal area in 33% of individuals; this variant of PAA is ideally appropriate to establish an extracranial-intracranial bypass when the vessel diameter is large enough. PAA usually terminates in the posterior auricular region in 67% (8,20).

1.3 PAA Branches

PAA divides into auricular and occipital branches; these branches usually arise superior to the mastoid tip to supply the digastric, stylohyoid, sternocleidomastoid muscles, and the parotid gland (6). The mean distance of the auricular branch above the mastoid tip was 0.68 cm, and the mean distance of the occipital branch above the mastoid tip was 0.84 cm (16). The former branches ascend the posterior auricular surface upward and vertically towards the helical rim, passing over the helical margin (20). The later branch can sometimes be palpated as it crosses the mastoid process (1).

The Transverse Nuchal is the third and terminal branch of PAA that anastomoses with the contralateral branch on the midline. And its presence makes the cutaneous territory of the PAA extend to an inferior strip below the OA's territory. Touré et al. reported the constant presence of this branch, although it was mentioned only once in the literature (26).

Some studies reported the presence of parotid and sternocleidomastoid branches separately in some dissections below the level of the mastoid tip (17). The Stylomastoid artery is a small branch that arises from PAA and enters the stylomastoid foramen with the facial nerve to supply the extracranial part of the nerve, the tympanic cavity, the mastoid antrum, and the semicircular canals (6,7). The stylomastoid artery originates from the PAA in 70% of the specimens, from the OA in 20%, and directly from the ECA in 10% in a study by Moreau et al. (17). Whereas, the stylomastoid artery originates from the OA in over than three-quarters of patients, and less commonly from the PAA in less than one-quarter of the patients, in another study by Upile et al. (Figure 1) (27).

PAA is the dominant artery supplying the ear, including retroauricular skin, in 93% of cases, in the other 7%, OA dominates (29). The angiosome of PAA is found to supply an area of 6*10 cm2, extend anteriorly from the tragus to 5 cm far from the external auditory canal posteriorly, and supply 6 cm inferior to the mastoid process (21).

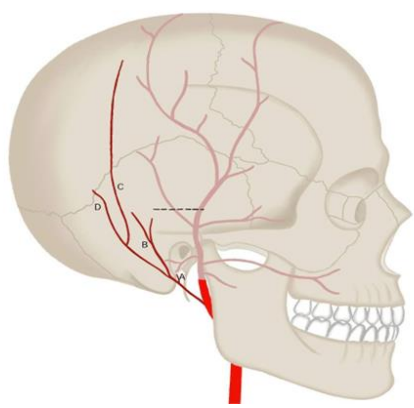

Figure 1. PAA main branches A; stylomastoid artery, B; auricular branch, C; transverse nuchal artery, D; occipital branch. Dotted line represents upper helix margin. Faded artery is superficial temporal artery.

PAA Length

PAA is acknowledged to be one of the ECA's small branches that supplies a small area behind the ear and parts of the external ear relatively (25). However, a recent study by Tokugawa et al. determined a variation in the length of PAA by classifying it into four main types, according to its length on the angiography, as shown in (Table.1). This classification did not include the diameter and the size of the PAA (24).

Table 1. Novel Classification of the Posterior Auricular Artery Based on Angiographical Appearance (24)

Type	Termination	Angiographical characteristics	%
A	between PAA origin and the center of the external auditory meatus	Short, slender, and sometimes so faint that cine angiography was needed for identification	15.1%
B	between the center of the external auditory meatus and the top of the helix	More obvious than Type A but still slender	34.9%
C	between the top of the helix and the vertex	Easy to identify but not as large as the superficial temporal artery or OA	48.8%
D	PAA reaches up to the vertex in	As large as, or sometimes larger, than the or OA	1.2%

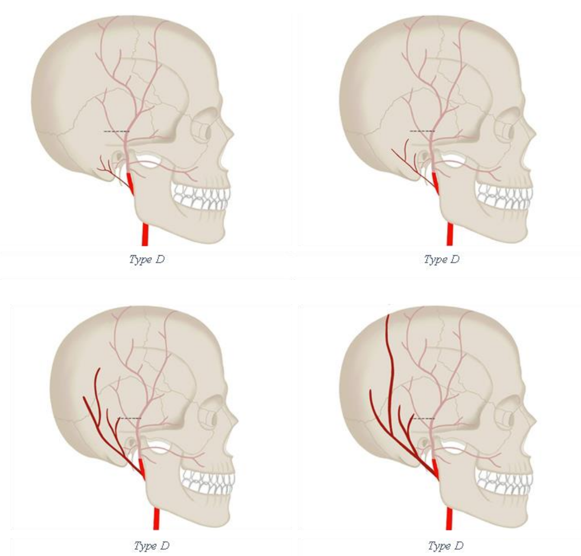

Figure 2. classification of PAA based angiografical appearance, type C,D are possible candidates for extracranial intracranial bypass for cerebral revascularization. Dotted line represents upper helix margin.

2. Neurosurgical applications

2.1 Bypass

PAA is considered as an extra-vessel within the scalp vasculature, which raises its importance as a donor artery (8). PAA variant that reach the temporoparietal area with at least 1 mm of diameter can be used for various extracranial-intracranial bypass surgeries;

this type of PAA has a prevalence of 5.7% (25). Usual arterial candidates for extracranial-intracranial bypass surgeries are the superficial temporal artery and to a lesser extent, OA can be used (9).

PAA can be used as a donor artery for extracranial-intracranial bypass revascularization surgeries for multiple cerebrovascular cases, including initial and refractory cases of moyamoya disease. Initial management by PAA was primarily in cases of an absent parietal superficial temporal artery, which was found in 50 autopsy specimens (13).

PAA-based bypass can also be used in intracranial aneurysm surgery with a decided sacrifice of the parent vessel. It can also be used in symptomatic atherosclerosis of internal carotid artery (ICA).

2.2 Embolization

Embolization of PAA has been reported in the literature in multiple aspects. Embolization of ECA for endovascular treatment of dural arteriovenous fistula or decompression of skull base tumors has some concerns, regarding extracranial-intracranial anastomosis routes to avoid the possible risk of embolic stroke or cranial nerve palsies (7). One of these anastomoses involves PAA extracranially through the stylomastoid artery that supplies cranial nerve VII. Proximal embolization of these arteries with particles can lead to temporary cranial nerve palsy, while distal embolization with either particles or liquid materials will lead to permanent cranial nerve palsy or can open connections with the intracranial contributions (22). Direct embolization of PAA as a feeder for dural arteriovenous malformation (AVM) has been reported to be safe, without significant complications or recurrence. However, Jankowitz BT et al, reported ear necrosis after onyx embolization of PAA for dural AVM (10).

2.3 AVM of PAA

AVM most commonly occurs intracranially, it is rare to occur in the head and neck region. A retrospective review of extracranial AVMs revealed 61% of external AVMs occur in the cheeks, followed by the ear area in 16% of cases, and the PAA is the main feeder artery (11). Traumatic AVMs of the PAA, unlike spontaneous ones, occur commonly in the head and neck area, most likely due to penetrating trauma (5). Both kinds of scalp AVMs present as pulsatile masses, palpable thrills, machine-like bruits, pulsatile tinnitus and cranial nerve compression. S W Cha et al, reported a 2-month-post-trauma PAA- internal jugular vein fistula (4).

Color doppler ultrasound guided by MRI, CT scan, and angiography is used to aid in the diagnosis of scalp AVMs (4). PAA could be a feeder artery for retroauricular AVMs or dural AVMs.

Management of the scalp PAA-originating AVM require total removal by excision or embolization of the feeder artery. Partial removal of such lesions could lead to recurrence (4).

2.4 Aneurysm of PAA

Aneurysms that originate from ECA and its branches are rare; they arise either due to atherosclerosis changes or trauma. Fibromuscular dysplasia is responsible for a small entity of ECA aneurysms. Traumatic pseudoaneurysms of PAA mostly present as auricular or retroauricular pulsating masses, with thrill and audiable bruit. Bleeding, compression symptoms could be other presentations for a PAA pseudoaneurysm. Management of ECA pseudoaneurysms, including PAA aneurysms, involves surgical repair or embolization. Wang D et al, stated that embolization of ECA pseudoaneurysms is a good alternative to open surgical management to avoid post-operative morbidity (28).

2.5 PAA flaps

Several PAA-based flaps have been used since sixties of the past century. PAA flaps are largely used for external ear, mastoid bowel reconstruction, and nose repair. Recent articles described island PAA flaps for face reconstruction. Pedicle PAA flaps for temoroparietal soft tissue grafting. McKinnon BJ confirmed the possibility of harvesting an 8*4 cm scalp pedicled flap based on PAA in the posterior auricular area, depending on the commonest PAA variant. A larger flap could result in arterial insufficiency with further distant skin necrosis and venous congestion (19). However, Lescour et al. (14) reported a case of PAA-dominant scalp vascularization that helped harvesting a 16 cm scalp flap based on PAA to reconstruct an occipital wound defect. Kolhe S P et al. (12) retrieved from dissection of 50 cadavers that a PAA variant with only a small auricular and stylomastoid artery as terminal branches, which resemble a type A variant, have no possibility of harvesting a flap. This type was encountered in 1.4% of his cadaveric studies.

Pericranial flaps

Dural defects and CSF leaks are major complications after skull base surgeries, in most instances, local vascularized pedicle percranial flaps are used. Percranial flaps are periosteal flaps for large dural defects. Stow NW et al. have described a smaller, deep periosteal branch of PAA running over the mastoid process and supplying mastoid cortex. As a result, the reconstructive potential of a PAA-based pericranial flap should be clearly considered (2).

Conclusion

The PAA has considerable variations in its surgical anatomy involving its origin, course, branches and length. This article aims to highlight the significance of PAA for neurosurgery procedures such bypass, embolization, aneurysm, and AVM surgery. These variations establish an important implication of PAA in the neurosurgical field. It is vital for neurosurgeons to have a complete understanding of the PAA's anatomical variances prior to any treatments, as these variations can affect the success and consequences of endovascular procedures.

References

1. Alvernia JE, Fraser K, Lanzino G. The Occipital Artery: Amicroanatomical Study. Operative Neurosurgery. 2006 Feb 1;58(suppl_1):ONS-114.
2. Archer SM, Jones RO. Traumatic pseudoaneurysm of the posterior auricular artery. Southern medical journal. 1992 Jan;85(1):47-8.
3. Beahrs OH, Adson MA. The surgical anatomy and technic of parotidectomy. Plastic and Reconstructive Surgery. 1958 Sep 1;22(3):276-7.
4. Bist SS, Saxena RK. Arteriovenous malformation and Color Doppler: posterior auricular artery. Indian Journal of Otolaryngology and Head and Neck Surgery. 2006 Jul 1;58(3):318-20.
5. Chae SW, Kang HJ, Lee HM, Hwang SJ. Tinnitus caused by traumatic posterior auricular artery–internal jugular vein fistula. The Journal of Laryngology & Otology. 2001 Apr;115(4):313-5.
6. Elvan Ö, Bobuş A, Erdoğan S, Aktekin M, Olgunus ZK. Fetal anatomy of the facial nerve trunk and its relationship with posterior auricular artery. Surgical and Radiologic Anatomy. 2019 Feb;41(2):153-9.
7. Geibprasert S, Pongpech S, Armstrong D, Krings T. Dangerous extracranial–intracranial anastomoses and supply to the cranial nerves: vessels the neurointerventionalist needs to know. American journal of neuroradiology. 2009 Sep 1;30(8):1459-68.
8. Germans MR, Regli L. Posterior auricular artery as an alternative donor vessel for extracranial-intracranial bypass surgery. Acta neurochirurgica. 2014 Nov;156(11):2095-101.
9. Horiuchi T, Kusano Y, Asanuma M, Hongo K. Posterior auricular artery-middle cerebral artery bypass for additional surgery of moyamoya disease. Acta neurochirurgica. 2012 Mar;154(3):455-6.
10. Jankowitz BT, Vora N, Jovin T, Horowitz M. Ear Necrosis Resulting from the Endovascular Onyx-18 Embolization of a Dural Arteriovenous Fistula Fed by the Posterior Auricular Artery. Journal of Neuroimaging. 2009 Jul;19(3):259-62.
11. Kim SH, Han SH, Song Y, Park CS, Song JJ. Arteriovenous malformation of the external ear: a clinical assessment with a scoping review of the literature☆. Brazilian journal of otorhinolaryngology. 2017 Nov;83:683-90.
12. Kolhe PS, Leonard AG. The posterior auricular flap: anatomical studies. British journal of plastic surgery. 1987 Nov 1;40(6):562-9.
13. Kurihara H, Yamaguchi K, Ishikawa T, Funatsu T, Matsuoka G, Omura Y, Okada Y, Kawamata T. Direct double bypass using the posterior auricular artery as initial surgery for moyamoya disease. Journal of neurosurgery. 2019 Aug 23;133(4):1168-71.
14. Lescour V, Perrot P, Ruiz F, Hamel A, Duteille F. Scalp flap pedicled on the posterior auricular artery. Anatomical study and clinical application. InAnnals of Aesthetic Plastic Surgery 2015 Jun 1 (Vol. 60, No. 3, pp. 235-241). Elsevier Masson.
15. Liu M, Wang SJ, Benet A, Meybodi AT, Tabani H, El-Sayed IH. Posterior auricular artery as a novel anatomic landmark for identification of the facial nerve: A cadaveric study. Head & neck. 2018 Jul;40(7):1461-5.
16. McKinnon BJ, Wall MP, Karakla DW. The vascular anatomy and angiosome of the posterior auricular artery: a cadaver study. Archives of facial plastic surgery. 1999 Jun 1;1(2):101-4.
17. Moreau S, Bourdon N, Salame E, Goullet de Rugy M, Babin E, Valdazo A, Delmas P. Facial nerve: vascular-related anatomy at the stylomastoid foramen. Ann Otol Rhinol Laryngol. 2000 Sep;109(9):849-52.
18. Newell DW, Vilela MD. Superficial temporal artery to middle cerebral artery bypass. Neurosurgery. 2004 Jun 1;54(6):1441-9.
19. Oufkir AA, Kajout M, Chadli R, Alami MN. Comments on the article "Scalp flap with pedicle on the posterior auricular artery. Anatomical study and clinical application ". InAnnals of Aesthetic Plastic Surgery 2015 Jun 1 (Vol. 60, No. 3, pp. 252-253). Elsevier Masson.
20. Pinar YA, Ikiz ZA, Bilge OK. Arterial anatomy of the auricle: its importance for reconstructive surgery. Surgical and Radiologic Anatomy. 2003 Aug 1;25(3-4):175.
21. Sharma RK, Pandey SK. Extended posterior auricular artery flap for coverage of a large temporo-parietal

defect. Journal of Plastic, Reconstructive & Aesthetic Surgery. 2010 Nov 1;63(11):e775-8.

22. Siddiqui AH, Chen PR. Intracranial collateral anastomoses: relevance to endovascular procedures. Neurosurgery Clinics of North America. 2009 Jul 1;20(3):279-96.
23. Tilotta F, Lazaroo B, Laujac MH, Gaudy JF. A study of the vascularization of the auricle by dissection and diaphanization. Surgical and radiologic anatomy. 2009 Apr;31(4):259-65.
24. Tokugawa J, Cho N, Suzuki H, Sugiyama N, Akiyama O, Nakao Y, Yamamoto T. Novel classification of the posterior auricular artery based on angiographical appearance. Plos one. 2015 Jun 1;10(6):e0128723.
25. Tokugawa J, Nakao Y, Kudo K, Iimura K, Esaki T, Yamamoto T, Mori K. Posterior Auricular Artery-Middle Cerebral Artery Bypass: A Rare Superficial Temporal Artery Variant with Well-developed Posterior Auricular Artery–Case Report. Neurologia medico-chirurgica. 2014;54(10):841-4.
26. Touré G, Méningaud JP, Vacher C. Arterial vascularization of occipital scalp: mapping of vascular cutaneous territories and surgical applications. Surgical and radiologic anatomy. 2010 Oct 1;32(8):739-43.
27. Upile T, Jerjes W, Nouraei SA, Singh SU, Kafas P, Sandison A, Sudhoff H, Hopper C. The stylomastoid artery as an anatomical landmark to the facial nerve during parotid surgery: a clinico-anatomic study. World Journal of Surgical Oncology. 2009 Dec;7(1):1-5.
28. Wang D, Su L, Han Y, Fan X. Embolization treatment of pseudoaneurysms originating from the external carotid artery. Journal of vascular surgery. 2015 Apr 1;61(4):920-6.
29. Wang Y, Zhuang X, Jiang H, Yang Q, Zhao Y, Han J, Yu D, Zhang Z. The anatomy and application of the postauricular fascia flap in auricular reconstruction for congenital microtia. Journal of Plastic, Reconstructive & Aesthetic Surgery. 2008 Jan 1;61:S70-6.
30. Zümre Ö, Salbacak A, Çiçekcibaşi AE, Tuncer I, Seker M. Investigation of the bifurcation level of the common carotid artery and variations of the branches of the external carotid artery in human fetuses. Annals of Anatomy-Anatomischer Anzeiger. 2005 Sep 1;187(4):361-9.