Double Internal Carotid Origin of the Ophthalmic Artery with Ruptured Aneurysm of the Posterior Communicating Artery

A Case Report

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Summary

We report a case of double origin of the ophthalmic artery from the carotid siphon. The persistence of the primitive dorsal ophthalmic artery, together with a ventral ophthalmic artery, constitutes the double origin of the ophthalmic artery. Remnant of intraorbital anastomoses formed by these two arteries is demonstrated. This represents a rare configuration of double origin of the arterial blood supply, which is discovered "incidentally" in a patient harboring a ruptured aneurysm of the posterior communicating artery.

The embryology of the ophthalmic artery and a possible association between vascular anomaly and arterial aneurysm can be envisaged.

Introduction

Double origin of the ophthalmic artery is a rare vascular anomaly. It could have several possible configurations which could be explained by the embryology of the arterial supply to the orbital territory. This case report illustrates a rare configuration of "double origin" of the ophthalmic artery which was discovered in a patient presenting with subarachnoid haemorrhage due to a ruptured aneurysm at the ipsilateral posterior communicating artery.

Case Report

A 66-year-old man was admitted because of subarachnoid haemorrhage which was confirmed by computed tomography. Digital subtraction angiography (DSA) showed a ruptured aneurysm at the junction of the right internal carotid artery (ICA) and the posterior communicating artery (figure 1). It measured about 7 mm x 6.5 mm. This was successfully embolized (95%) with coils. The patient recovered without neurological deficit. There was incidental finding of two branches arising from the supracavernous and intracavernous segments of right ICA respectively, coursing towards the orbital territory.

The upper artery originates from the ordinary origin of the ophthalmic artery, running an anterior and slightly inferior course towards the orbit via the optic canal. The lower artery arises from the posterolateral aspect of the intracavernous ICA, coursing superomedially towards the orbit, via the superior orbital fissure. Its origin corresponded to that of the inferolateral trunk.

There was a small anastomotic branch connecting the proximal part of the two arteries, which was demonstrated by three dimensional reconstruction of rotational DSA (figure 2B, C,D). On follow up angiography, there was no

evidence of recanalization in the embolized aneurysm (2A). The patient remained asymptomatic without neurological deficit.

Embryology of Ophthalmic Artery

At the 4 to 8mm stage of the human embryo, there are two anastomosing arteries supplying the orbit^{1,2}. One of them arises from the future anterior cerebral artery (ACA), the ventral ophthalmic artery. The other one originates from the intracavernous ICA, the dorsal ophthalmic artery. The former courses through the future optic canal, whereas the latter passes through the future superior orbital fissure to join the orbit.

Later in development, the proximal ventral ophthalmic artery anastomoses in the subarachnoid space with the supracavernous ICA; its proximal segment from the ACA subse-

Figure 1 Anteroposterior (A) and lateral (B) views of the right internal carotid angiogram show an aneurysm arising at the junction of internal carotid and posterior communicating arteries. Two branches are arising from the supracavernous and intracavernous segments of right ICA respectively, coursing towards the orbital territory.

Figure 2 Control angiogram of the right internal carotid artery (A) shows the embolized aneurysm. Three dimensional reconstruction of rotational angiogram of the carotid siphon demonstrated the lateral (B), medial (C) and superior (D) aspects of the two ophthalmic arteries.

Table 1 Sources of Double Supply to the Orbit

	VOP (ICA/ACA)*	DOP (ICA)	Stapedial artery (MMA)	Remarks
From ICA	+	+	-	Anastomosed
From ICA	+(Ciliary & Central retinal arteries)	+(Ciliary & OPHA trunk & branches)	-	Non-anastomosed
ICA + MMA	+	-	+	Anastomosed or Non-anastomosed
ICA + MMA	-	+	+	Anastomosed or Non-anastomosed

* depending upon the anastomosis at the clinoid level; Ventral ophthalmic artery (VOP), dorsal ophthalmic artery (DOP), middle meningeal artery (MMA), internal carotid artery (ICA), anterior cerebral artery (ACA), OPHA ophthalmic artery

* Persistent origin of VOP from ACA or complete "migration" onto the ICA does not change the orbital disposition.

quently regresses. Finally, the ventral ophthalmic artery arises from the supracavernous ICA siphon and is then known as the primitive ophthalmic artery. It forms an anastomotic ring with the dorsal ophthalmic artery inside the orbit around the optic nerve. Three branches arise from this ring: the temporal ciliary artery laterally, the nasal ciliary artery medially, and the central retinal artery².

The dorsal ophthalmic artery then involutes at the level of the superior orbital fissure. Its proximal remnant is the inferolateral trunk arising from the horizontal portion of the carotid siphon. The deep recurrent ophthalmic artery represents its distal intraorbital remnant. Finally, this leaves the commonly observed supracavernous origin of the ophthalmic artery in the adult^{2,3}.

At the 20 mm stage, the orbital branch of the stapedial artery enters the orbit through the superior orbital fissure and supplies the musculo-facial and glandular structures of the orbit. It divides into a medial ethmoidonasal and a lateral lacrimal arteries. The ethmoidonasal artery anastomoses with the primitive ophthalmic artery, forming a ring around the optic nerve. At a later stage only one of the branches of this ring remains. The anastomosis is most often located lateral to the optic nerve, corresponding to the lateral course of the final ophthalmic artery. At the 40 mm stage the transphenoidal part of the orbital artery regresses, leaving a

permanent anastomosis between the intraorbital ophthalmic system and the stapedial artery, which becomes at this level the middle meningeal artery^{2,3}.

Discussion

The ophthalmic artery usually originates from the internal carotid artery after it pierces the dura, emerging from the cavernous sinus on the medial side of the anterior clinoid process. Abnormal origins of the ophthalmic artery are closely related to its embryological anastomoses. Deviations from the usual sequence of development described above can lead to variations. All the anastomotic branches can potentially contribute to the creation of abnormal origin of the ophthalmic artery.

The most common variation is for the orbit to receive some or all of its blood supply from the middle meningeal artery. Accessory meningeal artery origin of the ophthalmic artery can be observed if the ventral ophthalmic artery regresses instead of the dorsal artery together with dominance of the accessory meningeal artery^{2,3}. The ophthalmic artery can rarely originate from the anterior cerebral artery if no anastomosis develops between the ventral ophthalmic artery and the carotid siphon⁴.

Double ophthalmic arteries arising from carotid siphon and middle meningeal artery are

not so rare whereas cases without contribution from middle meningeal artery are rarely reported. Persistence of the dorsal ophthalmic artery occurs when there is a failure of its regression at the superior orbital fissure.

The ophthalmic artery can arise from the intracavernous ICA as the only supply to the orbit or be part of a dual supply. Cases of double origin of ophthalmic artery from the carotid siphon without anastomosis between the ventral and dorsal ophthalmic arteries have been described^{2,7}. In our case, a small anastomosis can be demonstrated between the proximal part of the two ophthalmic arteries (figure 2). This is likely to be a remnant of the anastomotic ring formed between the primitive ventral and dorsal ophthalmic arteries around the optic nerve. The possible sources that can give rise to a double origin of ophthalmic artery are summarized in table 1.

There have been reports of origin of the ophthalmic artery from the middle cerebral artery⁵ and posterior communicating artery⁶, either associated with ipsilateral or both carotid arteries. They are, in fact, corresponding to the agenesis or hypoplasia of the first six segments of ICA, with the origin of the ophthalmic arteries being constituted by the distal (C7) segment of the ICA.

Vascular variants or anomalies are known to be associated with aneurysmal subarachnoid haemorrhage, and have been implicated in the pathogenesis of inherited intracranial aneurysms^{8,9}. It has been reported that vascular anomalies are present in more than eighty percent of patients with multiple intracranial aneurysms. A link between vascular anomalies and aneurysm location has been demonstrated in several vascular segments¹⁰.

Embryologically, the posterior communicating artery and the first segment of posterior cerebral artery constitute the caudal division of ICA². Therefore, in our case, the double origin

of the ophthalmic artery and the posterior communicating artery aneurysm represent anomalies of the same vascular segment. The anomaly of the vessel wall responsible of the aneurysm may correspond to a segmental vulnerability whereas the vascular anomaly of double origin of ophthalmic artery could represent a time marker¹⁰.

A case with multiple intracranial aneurysms associated with abnormal origin of ophthalmic arteries arising from the bifurcation of the internal carotid artery bilaterally has been described¹¹. Apart from arterial aneurysms, there has been report of arteriovenous fistula associated middle meningeal artery origin of ophthalmic artery¹².

Understanding the variations of arterial supply to the orbit is of particularly importance if surgery or therapeutic intervention is contemplated. In middle meningeal origin of the ophthalmic artery, the artery is at risk during operations directed along the sphenoid ridge¹³. During embolization procedures involving the branches of the external carotid artery such as embolization of meningiomas, the interventionist has to be cautious in preventing reflux into the ophthalmic artery.

Conclusions

A wide range of variations can occur in the arterial system of the orbital region. We report a rare variant of the orbital supply. The persistence of dorsal ophthalmic artery, together with a normally migrated ventral ophthalmic artery, constitutes the double origin of the ophthalmic artery arising from the carotid siphon. There is remnant of intraorbital anastomoses formed by these two arteries. The occurrence of a ruptured aneurysm at the posterior communicating artery is not surprising as vascular anomalies are associated aneurysmal subarachnoid haemorrhage.

References

- 1 Padgett DH: The development of the cranial arteries in the human embryo. *Contrib Embryolo* 32: 207-262, 1948.
- 2 Lasjaunias P, Berenstein A, terBrugge K: *Surgical Neuroangiography*. Springer, Berlin, Heidelberg 2002: 414-455.
- 3 Willinsky R, Lasjaunias P, Berenstein A: Intracavernous branches of the internal carotid artery (ICA). Comprehensive review of their variations. *Surg Radiol Anat* 9: 201-215, 1987.
- 4 Hassler W, Zentner J, Voigt K: Abnormal origin of the ophthalmic artery from the anterior cerebral artery: neuroradiological and intraoperative findings. *Neuroradiology* 31: 85-87, 1989.
- 5 Fisher AGT: A case of complete absence of both internal carotid arteries, with a preliminary note on the developmental history of the stapodial artery. *J Anat* 48: 37-46, 1913.
- 6 Priman J, Christie DH: A case of abnormal internal carotid artery and associated vascular anomalies. *Anat Rec* 134: 87-95, 1959.
- 7 Ogawa T, Miyauchi T et Al: Internal carotid origin of double ophthalmic arteries. *Neuroradiology* 32: 508-510, 1990.
- 8 Agnoli AL: Vascular anomalies and subarachnoid haemorrhage associated with persisting embryonic vessels. *Acta Neurochir (Wien)* 60: 183-199, 1982.
- 9 Miyazaki S, Kamata K et Al: Multiple aneurysms of the vertebrobasilar system associated with fenestration of the vertebral artery. *Surg Neurol* 15: 192-195, 1981.
- 10 Mazighi M, Porter PJ et Al: Vascular anomalies and the risk of multiple aneurysms development and bleeding. *Interventional Neuroradiology* 8: 15-20, 2000.
- 11 Hamada J, Kitamura I et Al: Abnormal origin of bilateral ophthalmic arteries. Case report. *J Neurosurg* 74: 287-189, 1991.
- 12 Watanabe A, Hirano K, Ishii R: Dural caroticocavernous fistula with both ophthalmic arteries arising from middle meningeal arteries. *Interventional Neuroradiology* 38: 806-808, 1996.
- 13 Liu Q, Rhoton AL Jr: Middle Meningeal Origin of the Ophthalmic Artery. *Neurosurgery* 49: 401-402, 2001.

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