Editorial Commentary

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Persistent trigeminal artery and its variants

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The Editor-in-Chief would like to comment on the persistent trigeminal artery and its variants in relation to the interesting article: "Coil embolization of multiple cerebral aneurysms with lateral type I persistent primitive trigeminal artery: a case report and literature review" by Dr. Wan et al.[1]

Association of the persistent trigeminal artery and cerebral aneurysm

There have been many papers on the persistent carotid-basilar (or carotid-vertebrobasilar) anastomoses, which are occasionally seen in association with cerebral aneurysms, arteriovenous shunts, intracranial tumors and other pathologies. Most of the associations have been believed to be incidental.[2] However, some papers suggest that there is a more than causal association of cerebral aneurysms with a variety of vascular variations including carotid-basilar anastomoses.[3–5] Some aneurysms could be flow related due to altered flow dynamics caused by vascular variations, while others have genetic predispositions from conditions like polycystic kidney and Marfan syndrome. Although the formation of aneurysms located at the trigeminal artery has an association with either structural and/or hemodynamic factors, the high incidence of their simultaneous existence in the same patients could still be attributable to selection bias. At present, it is still not clear whether these associations are incidental or inevitable.

Otic artery

Embryonal carotid-basilar anastomoses are arranged as proatlantal, hypoglossal, otic (acoustic) and trigeminal arteries in ascending order from the proximal to distal locations.[6] The otic artery is defined as the artery arising from the internal carotid artery within the carotid canal. It emerges from the internal acoustic meatus, and then joins the basilar artery as described by Lie.[7] However, the existence of the primitive otic artery is viewed with skepticism by some,[8] despite being reported in the literature. It is said that the so-called "otic artery" is a misinterpretation of the trigeminal artery with a relatively proximal arborization (a low-lying trigeminal artery). Embryologically, the optic placode and otic placode are supplied by the primitive ophthalmic artery and otic artery, respectively. The primitive ophthalmic artery runs through the optic canal with the optic nerve, and the otic artery exits the internal acoustic canal along with the vestibular nerve. These arteries have the similar role in supplying the placodes which are precursors of the sensory organs (lens and inner ear). In this sense, the otic artery may have no role to play in supplying the neural tube contrary to the other carotid-basilar anastomoses. The non-existence of the otic artery can be understood embryologically by considering the role of this artery in perfusing the otic placode (sensory organ). This is different from the remaining three primitive arteries, whose roles are to segmentally supply the brainstem (rhombomere and myelomere) and the high cervical spinal cord, respectively.

Classification of the trigeminal artery

This trigeminal artery has several classifications by various authors. As described in this paper,[1] Saltzman classically classified the trigeminal artery into three types in 1959.[9] Later, Salas et al.[10] classified it into two types: lateral (petrosal) and medial (sphenoidal) types. It is possible to classify it into completely different three types. The first type is the classic trigeminal artery directly connecting the internal carotid artery to the basilar artery. The second is a trigeminal artery variant purely supplying the cerebellum: trigemino-cerebellar arteries. These can be further classified into three types by their vascular territories (the superior cerebellar, anterior inferior cerebellar and posterior inferior cerebellar arteries). The third type is the trigeminal artery incorporated with the other two embryonic arteries, that is, the primitive stapedial artery and primitive ophthalmic artery, resulting in various complex arterial variants (opthalmo-steped-trigeminal, stapedo-trigeminal and staped-trigemino-cerebellar anastomosis). The opthalmo-steped-trigeminal anastomosis is the ophthalmic artery arising from the basilar artery.[11] The stapedo-trigeminal anastomosis is the middle meningeal artery arising from the basilar artery.[12] The stapedo-trigeminal-cerebellar anastomosis

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is the middle or accessory meningeal artery supplying the cerebellum.[13]

To these pre-existing descriptions, I would like to add another rare variant, which solely supplies the brainstem (pons) and does not directly connect to the basilar artery or cerebellar artery. This variant can be incorporated into the aforementioned second type, which purely supplies the brainstem or cerebellum. To my knowledge, this variant has not been reported in the literature. This variant implies that the trigeminal artery may potentially supply the brainstem even if there is no clear demonstration of this vessel on angiography (Figure 1).

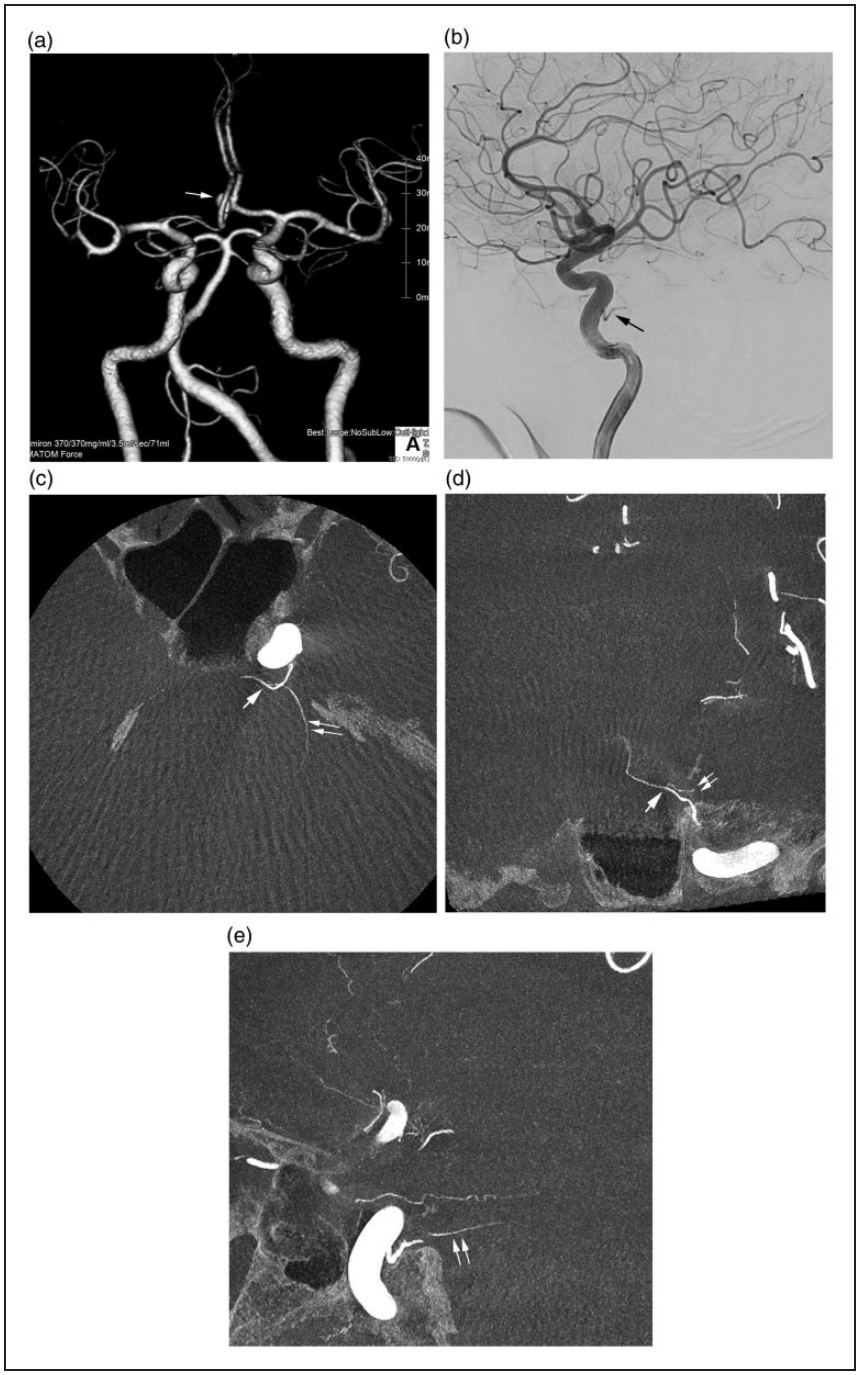

Figure 1. A small trigeminal artery variant exclusively supplying the brainstem in a 73-year-old man with an unruptured anterior communicating aneurysm. (a) CT angiography fails to show left trigeminal artery variant as well as anterior inferior cerebellar arteries bilaterally. Arrow indicates an unruptured anterior communicating aneurysm. (b) Left internal carotid angiogram (lateral view) showing a small artery at the C4 portion. However, its vascular territory is not clear. (c, d and e) The source images of the three-dimensional rotational angiography of the left internal carotid injection clearly show the trigeminal artery variant supplies exclusively the brainstem. Single arrows indicate the bifurcation of the trigeminal artery variant into the midline branch and circumferential branch (double arrows). Blood supply to the mid-pons from the trigeminal artery variant in this patient could be related to the non-visualization (hypoplasia) of bilateral anterior inferior cerebellar arteries.

Diagnosis of carotid-basilar anastomoses

Diagnosis of carotid-basilar anastomoses can be made with MR angiography, CT angiography and/or catheter angiography. However, precise anatomy of these vessels can only be demonstrated by the source images of CT angiography and/or three-dimensional rotational angiography. In particular, to adequately demonstrate this small artery branching off from the trigeminal artery requires the source images from three-dimensional rotational angiography. Recently, we encountered the small trigeminal artery variant exclusively supplying the brainstem, without direct communication with the basilar artery. There exists the potential for perforating arteries branching off from the trigeminal artery proper, which cannot be demonstrated by angiography.[10] In fact, in situ thrombosis of trigeminal artery is reported to cause perforating artery occlusion resulting in brainstem infarction.[14] It is necessary to recognize that any treatment of the aneurysm which affects the trigeminal artery and scars it may potentially cause brainstem infarction.

"Fetal type" and "Adult type" arteries

In the daily neuroradiological or neurosurgical work, we often use the terminology "fetal type" artery. The terminology of "fetal type" in this article[1] is used to describe the trigeminal artery, where blood supply to the vertebrobasilar territory depends on the internal carotid artery. This terminology is also commonly used for the posterior communicating artery similarly referred to as a fetal type of posterior communicating artery. The fetus is the name of the fertilized egg usually after two months (eight weeks) from conception in man. Before this timeframe (<2 months), it is called an embryo. Because all basic arteries at the base of the skull, such as the arterial circle of Willis, are formed in this embryonal period, they have the embryonal angioarchitecture at this stage. Such an arterial structure should therefore be called "embryonal type" instead of "fetal type" for more precise description of the embryology. When we mention a "fetal type" vasculature, we mean it in contrast to an "adult type" vasculature, which is not necessarily observed only in adults. Needless to say, there are both embryonal type vasculature and what is called an "adult type" vasculature seen in humans in adulthood. By the same reasoning, adult type vasculature could also be called "regressed type" vasculature for more precise adherence to the embryological principles.

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