Persistent Fetal Carotid –Vertebrobasilar Anastomoses and Other Anomalies-Pictorial Essay

Sagar Shetty1, Parangama Chatterjee2, Makarand Kulkarni3, Mehul Vikani4, Murtuza J5, Preeti Kapoor6, Hariprasad Shetty7

1Clinical associate, Dept of Radiology, Lilavati Hospital & Research Centre, Mumbai, India
2Consultant, Dept of Radiology, Lilavati Hospital & Research Centre, Mumbai, India
3Asst. Professor, Dept of General Surgery, MGM Hospital, Navi Mumbai, India
5Fellow, Dept of Ophthalmology, Narayan Netralaya, Bangalore, India
6Asso. Professor, Dept of Radiology, MGM Hospital, Navi Mumbai, India
7Asst. Professor, Dept of General Medecine, B.L Cooper Hospital, Mumbai, India

1drsrs87@gmail.com; 2parangamadr@gmail.com; 3makarand_kul@yahoo.com; 4mehulvikani@gmail.com; 5murtu.95@gmail.com; 6pritikaps@gmail.com; 7harrycool86@gmail.com

Abstract
MRA examination includes a review of three-dimensional and maximum intensity projection images of the intra- and extra cranial arteries to look for anomalies and normal variants like absence, duplication, persistent fetal arteries etc since it plays an important role in management of acute stroke and preoperative planning. Very often, these variants are associated with intracranial malformations like aneurysm, steal, or compression on cranial nerves. Hence, a neuroradiologist should have adequate knowledge of these normal variants which would help in management planning. This pictorial essay reviews various normal anatomical variants and congenital anomalies of internal carotid arteries.

Keywords
Persistent Trigeminal; Otic, Hypoglossal; Fetal Carotid –Vertebrobasilar Anastomoses; Fenestration; Absent ICA

Introduction
MRA examination includes a review of three-dimensional and maximum intensity projection images of the intra- and extra cranial arteries to look for anomalies and normal variants like absence, duplication, persistent fetal arteries etc since it plays an important role in management of acute stroke and preoperative planning. Very often, these variants are associated with intracranial malformations like aneurysm, steal, or compression on cranial nerves. This pictorial essay reviews various normal anatomical variants and congenital anomalies of internal carotid arteries.

Embryology
Padget [1] described the embryology and the various anatomic variations and persistent fetal intracranial anomalies. The forebrain is supplied by the carotid system during the 4mm embryo stage. Hindbrain is supplied by two longitudinal pair of arteries that run along its surface and ultimately join to form the basilar artery. There are four important arterial anastomoses i.e. the trigeminal artery, the otic artery, the hypoglossal artery, and the proatlantal intersegmental artery all of which supply the longitudinal neural arteries via carotid arteries. (Figure. 1). Posterior communicating artery is formed by the anastomosis between distal internal carotid artery and corresponding longitudinal neural artery, during 5-6 mm embryo stage. Later, the presegmental arteries and proatlantal intersegmental arteries regress and obliterate. Otic artery obliterates first which is followed by hypoglossal, trigeminal and lastly the proatlantal intersegmental artery. Until 7-12 mm embryo stage, the
Proatlantal intersegmental arteries supply the caudal part of neural arteries after which the vertebral arteries attain function.

Approximately at around 7- to 12-mm embryo stage, the basilar artery is formed by union of longitudinal neural arteries. The vertebral arteries are formed by union of multiple longitudinal anastomoses between adjoining cervical intersegmental arteries. (Figure 2). Rarely duplication of vertebral artery takes place if there is any malfunction in union at any level.

**Persistent Trigeminal Artery**

The incidence of persistent trigeminal artery reported is around 0.2%, though many times this condition goes undiagnosed and unreported since it does not produce any symptoms. Hence considering this fact the incidence might probably reach up to 1% [2]. Persistent trigeminal artery represents about 85% of the carotid-basilar anastomoses [2]. It takes it origin from the cavernous part of internal carotid artery in the region where it exits the carotid canal and enters the cavernous sinus. The trigeminal artery joins the basilar artery in either of two ways [3]. In about 50% of cases, the trigeminal artery pierces the sella turcica, courses in its own groove, and penetrates the dura near the clivus to eventually join the basilar artery between the anterior inferior cerebellar arteries and the superior cerebellar arteries. In the other 50% of cases, the trigeminal artery egresses from the cavernous sinus, runs along with the trigeminal root, or courses between the sensory trigeminal root and the lateral aspect of the sella, in a groove for the posterior petrosal process, the roof of which is formed by the petroclinoid ligament. It then unites with the basilar artery between the anterior inferior cerebellar arteries and the superior cerebellar arteries.

The persistent trigeminal artery links the cavernous internal carotid artery to the basilar artery (Figure 3). It is seldom associated with unilateral or bilateral hypoplastic vertebral arteries. Figures 4, 5, and 6 show MR angiogram images of the same.
Persistent Hypoglossal Artery

Persistent hypoglossal artery is the second most common type of persistent carotid-vertebrobasilar anastomosis. About 160 cases have been reported so far [2]. The hypoglossal artery arises from internal carotid artery at the level of C1 and C3 then passes through the hypoglossal canal to join the basilar artery [4] (Figure 7). It does not pass through the foramen magnum. One or both of the vertebral arteries may be aplastic or hypoplastic. Figures 8, 9 show MR angiogram images of the same.

**FIGURE 7. PERSISTENT HYPOGLOSSAL ARTERY WITH APLASTIC VERTEBRAL ARTERY**
Persistent Otic Artery

Till date very few cases have been reported [2], as very often this condition goes undiagnosed. In order to confidently diagnose this condition there are few criteria, mainly being the vessel should originate from petrous part of internal carotid artery i.e. it should be contained within the carotid canal and then course through the internal auditory canal and finally join the proximal basilar artery (Figure 10). A variant of otic artery often directly joins one of the cerebellar arteries.

Absent Internal Carotid Artery:

Congenital absence of internal carotid artery is a rare anomaly. To our knowledge, very few cases have been reported [5]. Frequently, these patients remain asymptomatic as a result of collateral circulation from the Circle of Wills and sometimes by persistent embryological vessels and transcranial collaterals via the ECA. Many theories have been put forward to explain the cause of absence, mainly being mechanical and hemodynamic stress on the embryo and also constriction of amniotic bands [6]. Sometimes these patients present with cerebrovascular insufficiency or complications related to aneurysms of collateral vessels or rarely congenital Horners syndrome [7]. The above is illustrated by Figures 11 and 12.
Fenestration

Fenestration is a segmental duplication of an artery resulting into two separate channels. Typical locations for fenestrations are anterior communicating artery, basilar artery and anterior cerebral artery. There are very few reports about fenestration of PCA with associated aneurysm (8, 9), with the exception of a report of fenestrated PCA associated with ruptured aneurysm in a child. (8). To our knowledge, there is only one report of fenestration of superior cerebellar artery (10).

The proximal basilar artery is the most frequent site of fenestration and saccular aneurysms frequently arise at the proximal end of the fenestration. The reported incidence of this association is 7% (11). The defect of the media at the junction of the fenestration and the stresses by the turbulent blood flow may increase the incidence of aneurysms at the fenestration site (9). However, aneurysms can also be seen at sites away from the site of fenestration; the incidence of aneurysms at the site of fenestration is not different from the typical association of other vessel bifurcations with saccular aneurysms. (11).

The above is illustrated by Figures 13 and 14.

Conclusion

Hence it is very important to identify these normal variants and congenital anomalies as it plays an important role in patient management. Though most of the times these patients are asymptomatic, sometimes they are associated
with intracranial malformations like aneurysm, steal, or compression on cranial nerves. Hence deriving this information is extremely useful as it helps in preoperative planning.

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CONFLICTS OF INTEREST

I hereby state that all the content and pictures used in this article are genuine and every author has contributed equally in writing this article. There are no conflicts of interest including any research funding, other financial support, and material support.

REFERENCES


Dr. Sagar Shetty MBBS, MD (Radio-Diagnosis) is a team spirited individual with special interest in musculoskeletal, gastrointestinal and chest imaging. He has done his fellowship in Body Imaging from the prestigious King Edward Memorial Hospital, Mumbai. He has also presented various papers in various conferences and has many publications to his name.