Vascular supply of the hindbrain

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The basic pattern of arterial vascularization is highly conserved across vertebrates and develops under neuromeric rules. The hindbrain has an angioarchitecture that is homologous to that of the spinal cord, and the hindbrain vascular system can be analyzed at the longitudinal and axial structures. The hindbrain vascular system can be analyzed at the longitudinal and axial structures. During the development, there are two main longitudinal anastomoses, i.e., ventral longitudinal neural artery (LNA) and primitive lateral basilovertebral anastomosis (PLBA).[1] Bilateral LNAs fuse and develop basilar artery (BA), and PLBA on the hindbrain wall links transiently the transverse branches of the LNA. The partial persistence of the PLBA is associated with some anatomical variations of the vertebrobasilar circulation.[1,2]

The perforators of the hindbrain follow the same pattern as that of the spinal cord. Supplying the hindbrain are three types of axial arteries: the paramedian, short circumferential artery, and long circumferential artery.[3] Puelles et al. have shown that paramedian (mediobasal and laterobasal) arteries directly penetrate the basal plate, while the short and long circumferential arteries supply the alar plate and correspond to ventroalar and dorsoalar arteries, which penetrate the spinal cord radially.[3] Circumferential branches of the BA and vertebral artery (VA) follow longer parallel courses relative to the dorsoventral dimension of all rhombomeres in order to supply their alar plate territories.[3]

In the early embryological period, the hindbrain is supplied by the carotid-vertebrobasilar anastomoses, which are arranged from rostral to caudal hindbrain as follows: the trigeminal, hypoglossal and proatlantal arteries (ProA). These transient anastomoses regress with the development of the posterior communicating artery (PcomA), and the BA is supplied from the VAs finally. [1,4,5]

Primitive lateral vertebrobasilar anastomosis (PLBA)

A longitudinal anastomosis temporarily present on the hindbrain wall connects the developing lateral branches of the LNA during arterial development (Fig. 3). Elze[6] in 1907 and Barniville[7] in 1914 discovered these vessels in the human embryo, and in 1948, Padget described it as PLBA. However, there have been only a few case reports of PLBA,[8,9] and even fewer discussing PLBA in detail.[2] There are many transverse channels between the LNA and

the PLBA, and many transverse branches from the PLBA supplying the dorsal part of the hindbrain. Some of these will later constitute the proximal segments of the cerebellar arteries.[1,10]

Fenestration/duplication of vertebrobasilar arteries

Fenestration or duplication of the BA occurs longitudinally, and the retention of different remnants of two axes (LNA and PLBA) can account for the various variations of BA, VA, and cerebellar arteries. BA is formed by fusion of the embryologic LNAs in a rostrocaudal direction by approximately the fifth week,[1] and PLBA is a primary longitudinal vessel that later acquires anastomoses with the LNA. Fenestration is one of the most common embryologic anomalies of the BA and is the result of incomplete fusion of the LNAs.[1] In a vertebrobasilar duplication, the lateral limb is a persistent segment of the PLBA, whereas the medial one corresponds to the VA.[2]

PTA variant

Analysis of the longitudinal and axial blood supply of the hindbrain helps to understand the pattern of PTA variants. The persistent PTA is the most common persistent primitive carotid- vertebrobasilar anastomosis with an incidence of approximately 0.5% to 0.7%.[11] The persistence of a direct anastomosis between the ICA and the cerebellar artery, without the interposition of the BA, was explained by an incomplete fusion of the LNAs.[12] Conversely, Gregg et al. proposed that PTA variants result from the partial persistence of the PLBA.[2] First, the PTA-cerebellar artery (SCA/AICA/PICA) variants result from the persistence of the part of the PLBA, and these variants occur when the transverse connection of the PTA to the LNA is absent.[2] Second, PTA-paramedian/circumferential variants are the result of incomplete fusion of the LNAs.[12] Depending on the site of incomplete fusion and remnant anastomoses, this may result in various patterns of PTA variants. (Fig. 5)

PHA variant

The persistent primitive hypoglossal artery (PHA) is the second most common persistent carotid-vertebrobasilar anastomosis with an incidence ranging from 0.027% to 0.29%.[13] An extremely rare PHA known as the PHA variant has been reported on a few occasions. This hypoplastic PHA directly ends in the PICA (PHA-PICA) without an interposed segment of the BA via the hypoglossal canal, which arise from the extracranial segment of the ICA[14,15] or the ECA[16].

Conclusion

The angioarchitecture of the hindbrain is homologous to the spinal cord and includes two main longitudinal arteries (LNA and PLBA). Partial persistence of the PLBA explains the formation of commonly observed variations, such as a fenestration and duplication of vertebrobasilar artery, PTA variant, or PHA variant. Understanding the pattern and the development of the blood supply of the hindbrain provides useful information of the various anomalies of the vertebrobasilar junction and cerebellar arteries.

Declaration of conflicting interests

The author declared no conflicts of interest.

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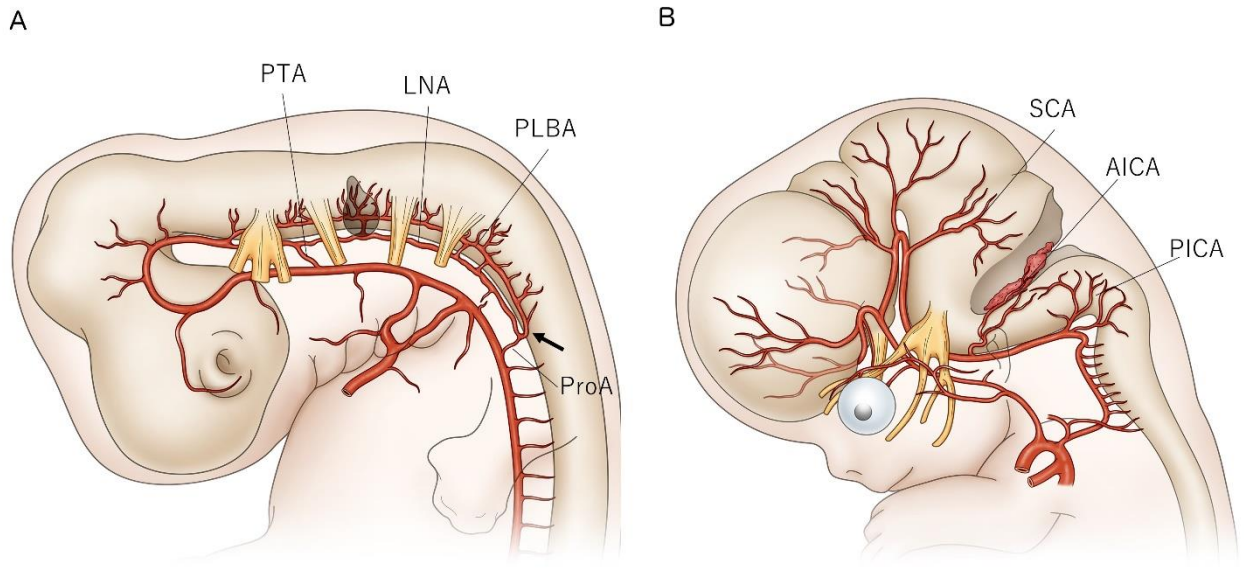

Fig. 1 Summary of the primitive lateral basilovertebral anastomosis (PLBA) development based on Padget's observations (Padget, 1948). [17]
(A) Representation of the cranial arterial system in embryos of CRL 5-7mmThe dorsal branch of the ProA connects directly to the PLBA, coursing cranially lateral to the LNA. A black arrow shows the dorsal branch of the ProA. The PLBA is a vascular network that later becomes a part of the cerebellar arteries.
(B) In an embryo of CRL 16-18mm. The SCA develops and is the only artery supplying the cerebellar rudiment. The AICA only has the choroidal branch, and the main trunk of the PICA is not formed and exists as a vascular network on the lateral side of the medulla. At this time, the AICA and PICA do not have branches to the cerebellum.
PTA: primitive trigeminal artery, ProA: proatlantal artery, SCA: superior cerebellar artery, AICA: anterior inferior cerebellar artery, PICA: posterior inferior cerebellar artery

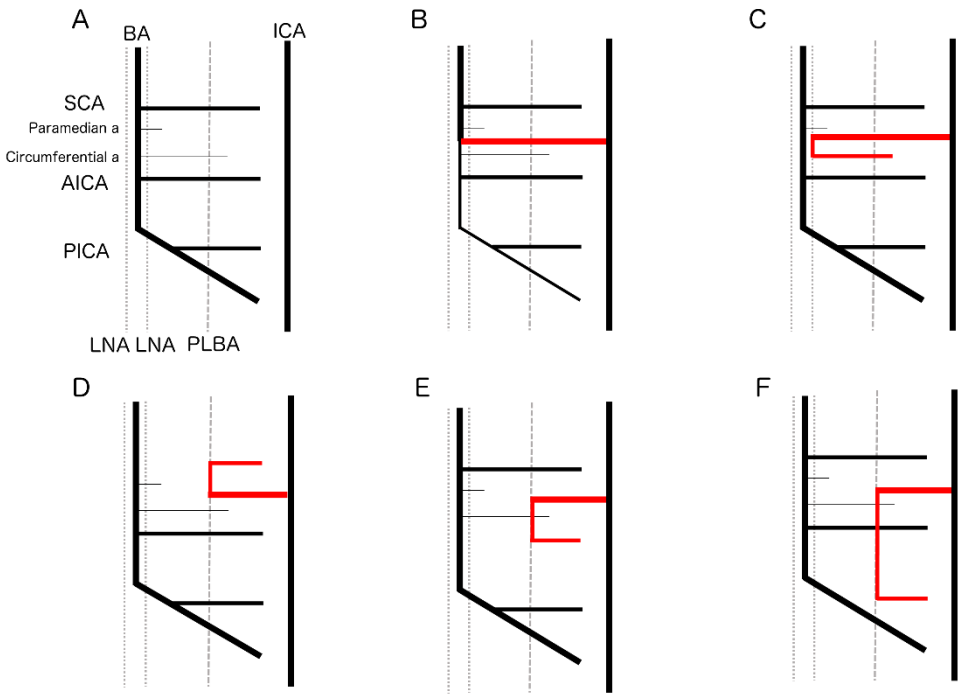

Fig. 2 Normal and variant PTAs[17]
(A) Normal development.
(B) Primitive trigeminal artery (PTA) red in color.
(C) PTA-circumferential variant, formed by the incomplete fusion of the longitudinal neural arteries (LNAs).
(D) PTA-superior cerebellar artery (SCA) variant, (E) PTA-anterior inferior cerebellar artery (AICA) variant, (F) PTA-posterior inferior cerebellar artery (PICA) variant. These variants are formed by the incomplete fusion of the primitive lateral basilovertebral anastomosis (PLBA). PTA-cerebellar arteries variants are formed by the persistence of the PLBA.