Human cadaveric study of the morphology of the basilar artery

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INTRODUCTION Nourishment for the brain, a highly vascular organ, is derived from a unique structure called the 'circle of Willis', which is formed by the terminal branches of the internal carotid arteries (ICAs) and basilar arteries (BAs). The circle of Willis forms an anastomotic link between the carotid and vertebrobasilar systems in the arterial supply of the brain, while the BA forms an important component of the brain's posterior circulation and supplies its many vital parts.
METHODS A study was performed on 20 brain specimens used for routine dissections at the Anatomy Department, Kasturba Medical College, in order to examine the morphology of BAs in the brain.
RESULTS In most specimens, the position of the termination of BA was normal, although variations were present in the mode of termination. In one specimen, the BA terminated by dividing into two superior cerebellar arteries. The posterior cerebral arteries (PCAs) arose from ICAs on both sides in this specimen, and a communicating branch was present between the terminal point of the BA and PCA on the left. In another specimen, unilateral variation was seen, with the PCA arising from the ICA on the right and a posterior communicating artery arising from the PCA, connecting it with the BA. The anatomy on the left side was normal.
CONCLUSION We highlight the morphological aspects of the BA, the knowledge of which would help neurosurgeons safely diagnose, as well as plan and execute vascular bypass and shunting procedures for the treatment of stenosis, aneurysms and arteriovenous malformations in the posterior cranial fossa.

Keywords: basilar artery, circle of Willis, internal carotid artery, posterior cerebral artery
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INTRODUCTION

Nourishment for the brain, a highly vascular organ, is derived from a unique structure known as the 'circle of Willis', which is formed by the terminal branches of internal carotid arteries (ICAs) and basilar arteries (BAs). The circle of Willis forms an anastomotic link between the carotid and vertebrobasilar system in the arterial supply of the brain.[1]

The BA is formed by the union of the right and left vertebral arteries at the pontomedullary junction. It runs over the ventral surface of the pons (pontomesencephalic junction) in a shallow median groove and terminates at the upper border of the pons by dividing into the right and left posterior cerebral arteries (PCAs), which pass ventral to the respective oculomotor nerves.[1] The BA forms an important component of the posterior circulation of the brain and supplies its many vital parts. Its area of distribution includes the internal auditory meatus, cerebellar hemisphere, paramedian areas of the pons, choroidal plexus of the third ventricle and crus cerebri. The areas supplied by its terminal branches are the thalamic nuclei, lateral geniculate body, choroidal plexus, epiphysis, mesencephalon and primary visual cortex.[2]

Normal morphology of the BA is an essential component of cerebral circulation since the hindrance of blood supply due to any cause, even for a short duration (7–8 minutes), would cause severe and irreversible damage to brain cells, which are very sensitive to hypoxia. Anatomical variations in the morphology of the BA is thought to be an aetiological factor for many clinicopathological conditions such as atherosclerosis, infarcts, arteriovenous malformations, transient ischaemic attacks and certain syndromes, including Wallenberg's syndrome, medial medullary syndrome and Weber's syndrome.[3]

The BA is a favoured site for atherosclerotic changes among the intracranial vessels, and the clinical manifestations of BA occlusive disease vary according to the site and nature of the vascular compromise. For instance, occlusion of the proximal and middle segments of the BA results in unilateral or bilateral pontine dysfunction, whereas distal occlusion produces signs of midbrain and thalamic ischaemia.[4] In view of the importance of the BA to the blood supply of the brain, we undertook a study to ascertain its morphology in the local population.

METHODS

This study was conducted on 20 brain specimens that were used and removed during routine dissections in the Department of Anatomy, Kasturba Medical College, Manipal, India. The area of the circle of Willis was cleaned after dissection by carefully removing the overlying meninges without damaging any of the vessels, thus exposing the BA. The arteries and their branches were painted red and allowed to dry for a period of time. The length of the BA was measured using a divider and ruler, and the angle of its formation estimated using a protractor. The level of

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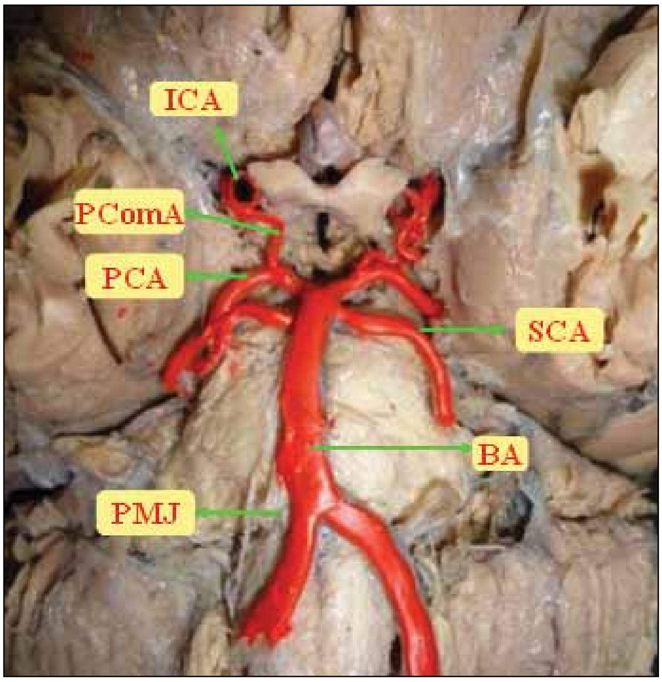

Fig. 1 Photograph shows the normal morphology of the basilar artery. BA: basilar artery; ICA: internal carotid artery; PCA: posterior cerebral artery; PComA: posterior communicating artery; PMJ: pontomedullary junction; SCA: superior cerebellar artery

its formation and termination were noted down. Any variations observed were also noted and photographed, and the data obtained were tabulated.

RESULTS

The normal morphology of the BA is shown in Fig. 1. The normal position of its formation was taken as the pontomedullary junction, while its normal position of termination was the upper border of the pons. Table I shows the length, angle of formation, and the positions of formation and termination of the BAs in our specimens.

The mean length of the BAs was 28.5 ± 2.8 (range 25–37) mm in our specimens, with the BA in specimen 4 measuring nearly 37 mm (Fig. 2). The mean angle of formation was 60° ± 8.7° (range 45°–70°). In most specimens (13/20, 65%), the position of formation of the BA was normal or at the pontomedullary junction. In five (25%) specimens, the position of formation of the BA was caudal to the normal position, while in two (10%) specimens, it was rostral to the pontomedullary junction. The position of termination of the BA was normal, at the upper border of the pons, in 14 (70%) specimens. The position of termination of the BA was caudal to the normal position in five (25%) specimens and just rostral to the normal level in one (5%) specimen.

In two specimens, although the position of termination of the BA was normal, there was variation in the mode of its termination. In specimen 6 (Fig. 3), the BA terminated by dividing into two superior cerebellar arteries. The PCAs were seen arising from the ICAs on both sides, and a communicating branch was present between the terminal point of the BA and PCA on the left side. In specimen 9 (Fig. 4), unilateral variation was seen in the mode of termination of the BA. On the right side, the PCA was seen arising from the ICA, and a posterior communicating artery arose from the PCA, connecting it with the BA. The anatomy on the left side was normal for this specimen.

Table I. Study findings on the basilar arteries in the specimens.

Specimen no.	Length of artery (mm)	Angle of formation	Level of formation	Level of termination
1	28	70°	Normal	Normal
2	25	60°	Normal	5 mm below normal
3	27	50°	5 mm below normal	Normal
4	37	45°	1 cm below normal	4 mm below normal
5	31	60°	Normal	Normal
6	28	60°	1 mm above normal	Normal
7	31	70°	Normal	Normal
8	25	70°	3 mm above normal	Normal
9	26	70°	Normal	3 mm below normal
10	32	60°	5 mm below normal	Normal
11	27	65°	Normal	Normal
12	30	60°	2 mm below normal	Normal
13	28	55°	Normal	Normal
14	26	70°	Normal	2 mm below normal
15	31	60°	3 mm below normal	Normal
16	28	50°	Normal	Normal
17	27	55°	Normal	Normal
18	26	45°	Normal	1 mm below normal
19	29	65°	Normal	Normal
20	29	60°	Normal	1 mm above normal

DISCUSSION

A wide range of variability, with regard to length, position and branching pattern, was seen in the BAs examined in our study. The average length of the BAs is about 32 mm, with a width of about 2.6–3.5 mm. Although variations in the length and position of BAs can be attributed to ageing and haemodynamic factors, variations in branching pattern are mostly congenital in origin, with embryological explanations behind them. A number of studies have reported on the length of the BA (Table II). For instance, a study of 83 specimens by Adachi in 1928 found that the average length of a BA was 25–30 mm.[5] In a much larger study of 1,000 specimens, Busch et al reported a mean length of 33.3 mm for the BA.[6] In a recent study, Padmavathi et al reported an average length of 25–38 mm.[3] Our results were similar to those of the abovementioned studies, with the length of BAs in our study ranging from 25 mm to 37 mm.

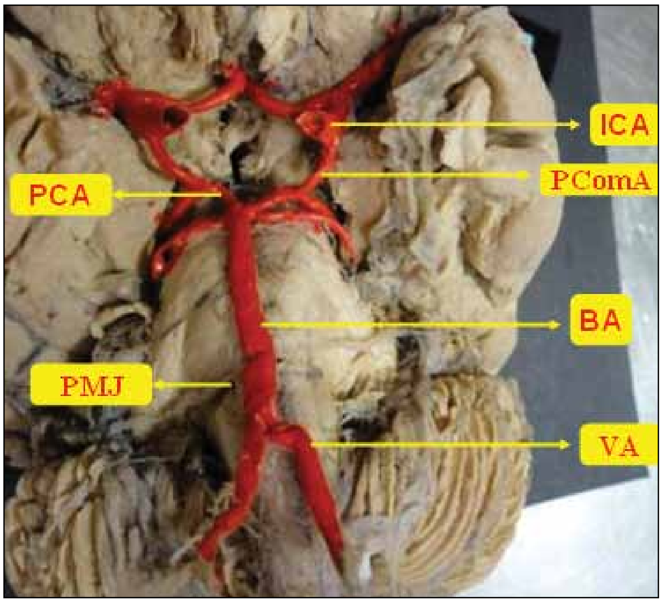

Fig. 2 Photograph of specimen 4 shows a long basilar artery forming below the pontomedullary junction.
BA: basilar artery; ICA: internal carotid artery; PCA: posterior cerebral artery; PComA: posterior communicating artery; PMJ: pontomedullary junction; VA: vertebral artery

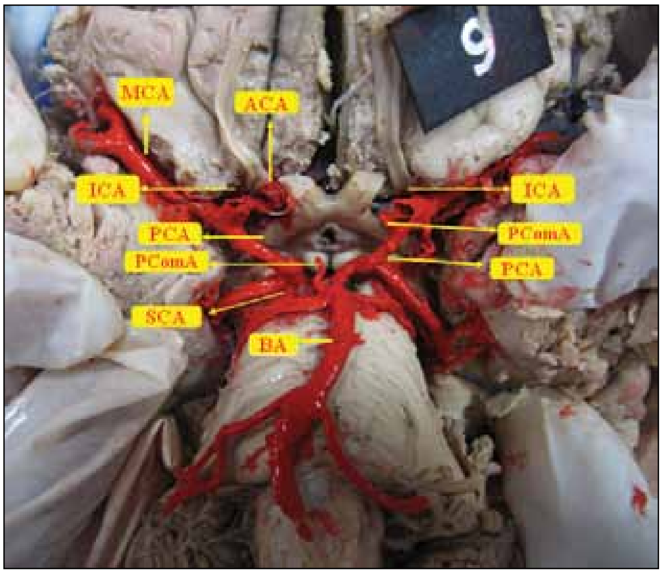

Fig. 4 Photograph of specimen 9 shows the posterior cerebral artery arising from the internal carotid artery only on the right side.
ACA: anterior cerebral artery; BA: basilar artery; ICA: internal carotid artery; MCA: middle cerebral artery; PCA: posterior cerebral artery; PComA: posterior communicating artery; SCA: superior cerebellar artery

According to a study by Clarke et al, the angle of formation of the BA ranged from 70° to 90°,[9] while Padmavathi et al found it to be between 50° and 90°, with the ideal angle of formation of the BA between 60° and 75°.[3] In our study, we found the angle to range from 45° to 70°. It has been suggested that the position of termination of the BA, as noted by Saeki and Rhoton,[7] may be as far caudal as 1.3 mm caudal to the pontomesencephalic junction, and as far rostral as the mamillary bodies. In a study of 160 specimens, Stopford et al found that the BA terminated at the upper border of the pons in 156 specimens and caudal to this position in the remaining four specimens.[10] We found that the BA terminated at the position of the upper border of the pons in 14 specimens, caudal to it in five specimens and just rostral to this position in one specimen.

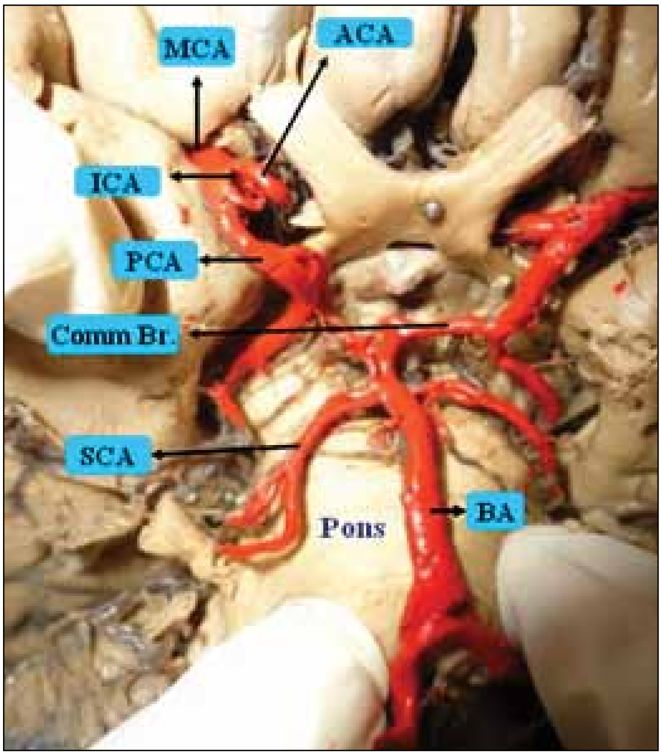

Fig. 3 Photograph of specimen 6 shows posterior cerebral arteries arising from the internal carotid arteries on both sides.
ACA: anterior cerebral artery; BA: basilar artery; ICA: internal carotid artery; MCA: middle cerebral artery; PCA: posterior cerebral artery; Comm Br: communicating branch; SCA: superior cerebellar artery

Table II. A review of studies on the basilar artery (BA).

Study (yr)	No. of specimens	Length of the BA (mm)
Adachi[5] (1928)	83	25–30
Busch et al[6] (1966)	1,000	33.3
Saeki and Rhoton[7] (1977)	50	15–40
Kamath[8] (1979)	100	22–45
Padmavathi et al[3] (2011)	54	25–38
Present study (2012)	20	25–37

The morphology of vessels such as the BA is of vital importance, as haemodynamic insults at arterial bifurcations are hypothesised to play a key role in intracranial aneurysm formation.[11] By extension, the length and angle of formation of the BA can be assumed to determine the flow of blood and its haemodynamic effect on the vessel walls. The positions of formation and termination of the BA have implications for the pathogenesis of occlusive disorders, site of aneurysm initiation and its progression into a giant fusiform aneurysm.[11] For instance, in the limited medial (tunica media) defect, the site of aneurysm initiation might be embryologically ascribed to the persistence of morphological individuality in the tunica media of the two branches at the point where the fusion of primitive longitudinal arteries (precursor of the BA) stopped.[12] The position of termination of the BA also determines the type of approach to be taken for the treatment of aneurysms of the basilar apex and those involving the PCA, as efforts need to be made to minimise or prevent damage to nearby important structures such as the mammillary body and optic chiasma.[3]

Embryologically, the BA develops from a fusion of bilateral longitudinal channels, which differentiate along the ventral surface of the hindbrain. This establishes connections with the caudal division of the ICA cranially and the vertebral artery caudally before fusion. A caudal division of the ICA later differentiates into the posterior communicating artery and the stem of the PCA. Thus, the presence of a PCA arising from the ICA in adults is often considered to be due to the persistence of a foetal arrangement of vessels.[13] The foetal type of the PCA acts as an impediment to blood supply in the respective hemisphere, so that the opposite hemisphere gets better blood supply, as it is supplied by both the BA and ICA.[13] The existence of foetal types of the PCA has been documented.[13] In the present study, we came across two specimens with such a variation, with the variation being unilateral in one and bilateral in the other.

In conclusion, the morphological aspects of the BA in the local population were highlighted in this cadaveric study. Detailed knowledge of the course of the BA would help neurosurgeons safely diagnose, as well as plan and execute vascular bypass and shunting procedures for the treatment of stenosis, aneurysms and arteriovenous malformations in the posterior cranial fossa.

REFERENCES

1. Williams PL, Dyson M, Collins P, Bannister, eds. Gray's Anatomy. 40th ed. New York: Churchill Livingstone, 1995: 390.
2. Papantchev V, Hristov S, Todorova D. Some variations of circle of Willis, important for cerebral protection in aortic surgery – a study in Eastern Europeans. Eur J Cardiothorac Surg 2007; 31:982-9.
3. Padmavathi G, Rajeshwari T, Niranjana Murthy KV. Study of the variations in the origin & termination of basilar artery. Anatomica Karnataka 2011; 5:54-9.
4. Morales-Vidal S, Flaster M, Biller J, Levine SR. Basilar artery stroke. In: Neurology Medlink [online] Available at: www.medlink.com/medlinkcontent.asp. Accessed November 11, 2012.
5. Adachi B. Das Arteriensystem der Japaner. Verlag der Kaiserlich-Japanischen Universitat zu, Bd II, Kyoto, 1928.
6. Inui H, Kikuoka M, Fujita N, Yoshii I. [Three-dimensional analysis of arteriography in human posterior circulation. (preliminary report)] Nihon Jibiinkoka Gakkai Kaiho 1992; 95:1206-15. Japanese.
7. Saeki N and Rhoton AL Jr. Anatomy of posterior circle of Willis. J. Neurosurg 1977; 46:564-78.
8. Kamath S. A study of dimensions of the basilar artery in South Indian subjects. J Anat Society of India 1979; 28:45-64.
9. Pessin MS, Kwan ES, DeWitt LD, et al. Posterior cerebral artery stenosis. Ann Neurol 1987; 21:85-9.
10. Stopford JS. The arteries of the pons and medulla oblongata. J Anat Physiol. 1916; 50:131-64.
11. Gao L, Hoi Y, Swartz DD, et al. Nascent aneurysm formation at the basilar terminus induced by hemodynamics. Stroke 2008; 39:2085-90.
12. De Caro R, Serafini MT, Galli S, et al. Anatomy of segmental duplication in the human basilar artery. Possible site of aneurysm formation. Clin Neuropathol 1995; 14:303-9.
13. Lodder J, Janevshi S, van der Lugt PJ. Megadolicho vascular malformation of the intracranial arteries. Clin Neurol Neurosurg 1981; 83:11-8.