SECTION - 4

The arterial supply of the brain of slender loris
(Loris tardigradus lydekkerianus)
INTRODUCTION


Among the subhuman primates, investigations on the vascular supply of simian brains have been conducted by Grunbaum et al. (1902), De Vriese (1905), Shellshear (1927), Critchley (1930), Shellshear (1930), Watts (1934), Sakuma (1961), Weinstein et al. (1962) and Neal et al. (1965). Similar studies on the prosimian brains are very limited and they include the investigations on Perodicticus potto and Lemur (Beddard, 1904).
**Nycticebus coucang** (Davis, 1947 and Krishnamurti, 1968) and *Galago senegalensis* (Kanagasuntheram et al. 1965). Therefore, the arterial supply of the brain of slender loris hitherto not reported, is undertaken in the present study.

**MATERIALS AND METHODS**

The arterial supply of the brain was studied in three anaesthetized animals using vascular injection technique (Choudhury et al. 1978). A solution of coloured cellulose acetate moulding granules (CAMG) was prepared by dissolving 10 gms of CAMG in 100 ml of acetone and injected through the ascending aorta at a pressure of 105 to 110 mm of mercury. In one specimen Indian ink was injected to study the finer branches. To ensure satisfactory injection of the blood vessels of the head and neck region and particularly brain, the proximal part of the descending aorta was ligated prior to the injection. The animal was immersed in 10% formal saline to allow for the setting of the injected material. The following day the brain was removed and the cortical areas supplied by various cerebral arteries were outlined. Dissection of the circle of Willis and its major branches was done in one specimen using a dissection microscope. Relevant brain materials were photographed in standard views.
The source of arterial blood for the brain of slender loris is derived from the intracranial part of internal carotid and vertebral arteries. Branches of these arteries form two arterial circles in the base of the brain (Plate 7, Fig. 37).

**THE INTRA-CRANIAL PART OF THE INTERNAL CAROTID ARTERY**

The internal carotid arteries of the right and left side lie close to optic chiasma and divide into three major branches namely the anterior cerebral, middle cerebral and posterior communicating arteries (Plate 7, Fig. 37). Apart from these branches a few smaller branches are given off from the main artery which supply the hypophysial and optic chiasma region.

**The anterior cerebral artery**

In two of the three brains studied the anterior cerebral arteries were of equal size while in one specimen the left anterior cerebral artery was very much reduced in size in comparison to that of the right side. From the point of origin, both the right and left anterior cerebral arteries run medially towards the olfactory tubercle and ascend upwards in between the olfactory bulbs, for a distance of about 2 mm beyond which
PLATE - 7

BLOOD SUPPLY OF THE BRAIN OF SLENDER LORIS

Fig. 36. Medial view of the left hemisphere.
Fig. 37. Circle of Willis and its branches.
Fig. 38. Medial view of the right hemisphere.
Fig. 39. Right inferolateral view of the brain.
Fig. 40. Base of the brain.
Fig. 41. Left inferolateral view of the brain.
Fig. 42. Superior view of the cerebellum and brain stem.
Fig. 43. Ventral view of the cerebellum and brain stem.
Fig. 44. Dorsal view of the cerebellum and brain stem.

KEY TO ABBREVIATIONS

AC  Anterior cerebral artery.
ACh  Anterior choroidal artery.
BA  Basilar artery.
C  Communication between posterior communicating arteries.
CM  Callosomarginal branch of the anterior cerebral artery.
IC  Internal carotid artery.
Lo  Arterial loop near the origin of Basilar artery.
M  Medulla oblongata.
MC  Middle cerebral artery.
mct  Median trunk of the anterior cerebral artery.
Olb  Olfactory bulb.
Po  Posterior communicating artery.
Sc  Spinal cord.
Sca  Superior cerebellar artery.
VA  Vertebrai artery.
VIII  Vestibulo cochlear nerve.
Acc  Accessory nerve.
DISTRIBUTION OF ANTERIOR AND MIDDLE CEREBRAL ARTERIES IN THE BRAIN OF SLENDER LORIS

Fig. 45 to 51. Various views of the brain to show the area of distribution of anterior and middle cerebral arteries.

KEY TO ABBREVIATIONS

AC  Anterior cerebral artery.
MC  Middle cerebral artery.
OIB  Olfactory bulb.

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they unite to form a single trunk (Plate 7, Fig. 36 to 38). This median trunk situated in front of the anterior commissure, runs vertically upwards and reaches the dorsal surface of the genu of the corpus callosum (Plate 7, Fig. 36) where it gives off two large callosomarginal branches one for each hemisphere. The trunk then continues its further course on the dorsal surface of the corpus callosum which it supplies and eventually winds around the splenium to terminate by dividing into three terminal branches.

**Branches of anterior cerebral artery**

1) Near the lateral border of the optic chiasma a small branch is given off which runs medially to meet the fellow of the opposite side to form a plexus on the ventral surface of the optic chiasma. This plexus supplies the optic chiasma, optic nerve, septum pellucidum, supra and preoptic regions of the hypothalamus. The caudal part of this plexus encircles the pituitary stalk and anastomoses with the hypophysial branches of the posterior communicating artery.

11) A small branch which supplies the olfactory tubercle and the pyriform cortex in the base of the brain anastomoses with the similar branches of the middle cerebral artery.
III) The third branch is the recurrent branch which arises at the point where the anterior cerebral artery turns vertically to enter the median sagittal fissure. From its origin the artery passes posterolaterally to reach the vallecula Sylvi and enters the anterior perforated substance of the brain to supply the deep structures.

iv) Anterior communicating branch is a small artery which connects the right and left anterior cerebral arteries near the olfactory tubercle.

v & vi) Medial and lateral olfactory branches arising from the anterior cerebral artery, supply the medial and lateral surfaces of the olfactory bulb (Plate 7, Fig. 36 & 38).

Branches of the single median trunk:

1) Olfactory branch, which is larger than the medial and the lateral olfactory branches described already, runs forwards on the medial surface of the cerebral hemisphere in the fissura rhinalis anterior (Plate 7, Fig. 36 & 38). It supplies the dorsal surface of the olfactory bulb and the orbital surface of the cerebral hemisphere near the frontal pole.
ii) Frontopolar branch which arises near the rostral end of the sulcus cinguli (cg), runs as far up to the frontal pole (Plate 7, Fig. 36 & 38). It supplies the medial surface of the anterior most part of the cerebral hemisphere and anastomoses with other cortical branches of the anterior cerebral artery (Plate 7; Fig. 38).

iii) The callosomarginal branch is the largest branch of the median trunk, one for right and one for the left side and supplies major part of the medial surface of the cerebral hemisphere. From its origin it runs backwards in the sulcus cinguli and gives off cortical branches (Plate 7, Fig. 36 & 38), all of which supply the medial surface and a part of superolateral surface of the cerebral hemisphere (Plate 8, Fig. 49) for a distance of 5 to 6 mm from the midline, where they anastomose with the cortical branches of the middle cerebral artery. The terminal part of the callosomarginal branch runs towards the occipital pole and then gains entry on to the superolateral surface where it anastomoses with the terminal part of the middle cerebral artery (Plate 8, Fig. 49 & 51). Thus the anterior cerebral artery supplies a strip of cortex on the superolateral surface of the cerebral hemisphere from frontal pole to occipital pole.
A few cortical branches which run towards the retrocalcarine fissure, anastomose with the branches of the posterior cerebral artery.

iv) The terminal three branches of the median trunk are given off at the posterior surface of the splenium of the corpus callosum. One of these three branches curves around the splenium of the corpus callosum and supplies the choroid plexus of the third ventricle and body of the fornix. The second branch supplies the posterior part of pulvinar of the thalamus. The third one supplies the cortex around the precalcarine fissure and anastomoses with the cortical branches of the terminal part of the callosomarginal artery.

**The middle cerebral artery**

It is the second major branch of the internal carotid artery (Plate 7, Fig. 37) and courses towards the superolateral surface following the Sylvian fissure. On its way it gives off cortical branches to the orbital and superolateral surfaces of the cerebral hemisphere and finally reaches the terminal part of the Sylvian fissure (Plate 8, Fig. 45 to 50). Here it takes an arched course and breaks up into its terminal branches which supply the superolateral surface of the occipital lobe (Plate 8, Fig. 48 to 51).
Branches of the middle cerebral artery:

1) Central branches are given off in the region of the anterior perforated substance to supply the deep nuclear mass in this area. Two of them are large and enter into a depression which lies between the olfactory tubercle and the posterior end of the olfactory tract.

11) The olfactory bulb receives a branch which supplies the lateral surface and anastomoses with the olfactory branches of the anterior cerebral artery (Plate 8, Fig. 45).

111) Cortical branches of the middle cerebral artery run on either borders of the Sylvian fissure. There are seven or eight branches which supply the major part of the orbital and superolateral surface of the cerebral hemispheres, and the temporal pole (Plate 8, Fig. 45). All those cortical branches which run towards the superomedial border anastomose with the cortical branches of the anterior cerebral artery. The branches which run towards the inferolateral border on the temporal lobe anastomose with the cortical branches of the posterior cerebral artery along this border (Plate 3, Fig. 45). The middle cerebral artery supplies the entire superolateral surface of the cerebral cortex excepting a strip of cortex along the median sagittal fissure which is supplied by anterior cerebral artery.
**Posterior communicating artery**

This is the third major branch of the internal carotid artery and runs backwards along the temporal lobe to reach the ventral surface of the crus cerebri of the midbrain, where it communicates with the posterior cerebral artery (Plate 7, Fig. 37).

**Branches of posterior communicating artery:**

1) Anterior choroidal branch arises from the dorsal surface of this artery and runs towards the hippocampus and enters the inferior horn of the lateral ventricle to supply the choroid plexus and the deeper structures around it.

2) There is a large branch which runs transversely lying along the posterior border of the hypophysis cerebri which connects the posterior communicating artery of the opposite side. This divides the circle of Willis into two subcircles (Plate 7, Fig. 37).

3) Central branches are distributed to the tuberculum cinereum, pituitary body and the posterior part of the hypothalamus.

**Vertebral artery**

The vertebral arteries of the right and left side enter the skull lying lateral to the caudal end of the medulla and anterior to the spinal part of the accessory nerve (Plate 7, Fig. 39 & 41). Further onwards they lie in close contact
with the medulla oblongata before they reach the midline to form the basilar artery at the level of the upper part of the closed medulla (Plate 7, Fig. 40).

Branches of the vertebral artery:

1) Three or four small branches arise near the ventral surface of the medulla. One among them is larger than the others and which arises close to the emergence of the XII cranial nerve rootlets, supplying them and the ventral and dorsal surfaces of the medulla. It anastomoses with the other branches of the vertebral and basilar arteries on the ventral surface of the medulla (Plate 7, Fig. 39 to 41).

11) Anterior spinal branch (Plate 7, Fig. 43) arises from the medial border of the vertebral artery and meets with the similar branch of the opposite side to form the anterior spinal artery, which runs downwards in the anterior median fissure of the medulla and the upper part of the cervical spinal cord and supply them. Beyond this, the anterior spinal artery gets reinforced by third cervical spinal segmental artery.
BASILAR ARTERY

This artery is formed at the anterior median fissure of the medulla and runs rostrally where it lies on the basilar groove of the ventral surface of the pons (Plate 7, Fig. 43). In one specimen there was an arterial loop near the origin of the basilar artery (Plate 7, Fig. 37). The basilar artery terminates near the upper border of the pons by dividing into a right and left posterior cerebral arteries.

Branches of the basilar artery:

1) Five to six branches arise on either side of the basilar artery which anastomose with each other and supply the ventral surface of the pons and upper part of medulla. Among them two are larger and running transversely one lying rostral to and another caudal to the trapezoid body (Plate 7, Fig. 40 & 41) and anastomosing with one another medial to the flocculus. The rostral one supplies the VII, & VIII cranial nerves and the caudal branch supplies the choroid plexus of the IV ventricle by sending branches through the lateral foramen. The caudal branch, in addition, anastomoses with a branch from the vertebral artery deep to the cranial part of the accessory nerve rootlets as the nerve emerges from medulla.
ii) Two or three central branches, arising from the dorsal surface of the basilar artery at the point of its terminatio supply the posterior perforated substance of the mid brain

iii) Superior cerebellar arteries arise from the basilar artery very close to its termination. It runs dorsally to reach the superior surface of the cerebellum which it supplies (Plate 7, Fig. 42). The artery then takes an oblique route and crosses the biventral lobe to reach the inferior surface of the cerebellum which also it supplies (Plate 7, Fig. 44). There is no inferior cerebellar artery in slender loris.

iv) Mesencephalic branches are two in number and supply the lateral surface of the crura cerebri and the colliculi of midbrain.

v) Posterior cerebral branch is the largest and terminal branch of the basilar artery and runs in close relation to the hippocampus (Plate 7, Fig. 36 & 37). It is connected to the internal carotid artery of the same side by the posterior communicating artery, near its origin. After giving off posterior choroidal and a few branches to the interpeduncular fossa, the artery runs posteriorly on inferior
surface of the cerebral hemispheres to supply this area. It terminates near the retrocalcarine fissure by breaking up into terminal branches. The terminal branches of the posterior cerebral artery anastomose with that of the middle cerebral on the inferolateral border of the temporal and occipital lobes (Plate 8, Fig. 45). On the inferior surface it anastomoses with the branches of the anterior cerebral artery near the pre and retrocalcarine fissures.

**DISCUSSION**

The interesting feature exhibited by the circle of Willis in slender lorises is the presence of a transverse connection between the two posterior communicating arteries which divide the circle into two subdivisions. Although similar subdivision is seen in slow lorises, the formation of the subdivision is a result of the anastomosis between the optic rami arising from the intracranial part of internal carotid artery of both sides. Nevertheless, the subdivision of circle of Willis into two subcircles appears to be a constant feature exhibited by the lorises.
Among the three specimens studied the anterior cerebral artery was found to be extremely small in one case. Such a reduction in the size of the anterior cerebral artery was also observed in man and was found to be more common on the left side (Jayasree et al. 1981).

In slender lorises the right and left anterior cerebral arteries unite to form a single median trunk rostral to anterior commissure. The presence of such a median trunk appears to be a normal feature of some of the subhuman primates as reported in anthropoid apes by Grunbaum et al. (1902), in Cebidae by Critchley (1930), in Cercopithecidae by Watts (1934), in Macaca Cyclops by Sakuma (1961), and in Nycticebus coucang by Krishnamurti (1968a). Variation in the normal pattern of the anterior cerebral artery in human brain resulting in this pattern of single median trunk were also reported (Whitfield 1893, Blackburn 1907, Stopford 1916, Raja Reddy et al. 1972 and Jayasree et al. 1981).

Eventhough the slender loris and slow loris show fusion of the anterior cerebral artery, the point of union differs in these two animals. In slender loris the point of fusion is near the anterior commissure, where as in slow loris the fusion occurs near the genu of the corpus callosum (Krishnamurti, 1968a). In Macaca cyclops the fusion occurs rostral to the
anterior commissure (Sakuma, 1961) and hence resemble the
pattern seen in slender loris. The fused median trunk of the
anterior cerebral artery does not divide again in slender loris,
whereas in slow loris the fused median trunk again divides
into a right and left anterior cerebral artery at the level
of the middle of the body of corpus callosum (Krishnamurti,
1966a).

The area of the cerebral cortex supplied by the anterior
cerebral artery on the superolateral surface of the brain
in slender loris extends from frontal pole to occipital
pole, whereas in Nycticebus coucang and Macacus cyclopsis
superalateral
a small area on the surface near the occipital
pole is supplied by posterior cerebral artery,(Krishnamurti,
1968a and Sakuma, 1961) thereby indicating that the visual
cortex is less elaborate in slender loris in comparison to
slow loris.

The middle cerebral artery supplies the entire supero-
lateral surface of the cerebral cortex excepting a strip
of the cortex along the superomedial border supplied by the
anterior cerebral artery mentioned above. In this respect
it differs from Nycticebus coucang (Krishnamurti, 1968a)
and *Macacus cyclops* (Sakuma 1961) where a portion of the inferior temporal gyrus along the inferolateral border is supplied by posterior cerebral artery.

The formation of the basilar artery by the union of right and left vertebral arteries takes place at the level of the upper part of closed medulla in slender loris. In the case of *Nycticebus coucang* (Krishnamurti, 1968a) and *Macacus Cyclops* (Sakuma, 1961) the formation of basilar artery is at a higher level at the ponto medullary junction. In the lower mammals the formation of the basilar artery is at the level of first cervical nerve as reported in blue fox by Wiland (1966). Moreover, in one brain of slender loris there was a small arterial loop near the origin of basilar artery. Such an arterial loop was also observed in one of the brain of slow loris examined by Krishnamurti (1968a).

In the animals belonging to the family *Canidae* the basilar artery is formed by the union of cervico spinal artery a branch from occipital artery and third cervical spinal branch of vertebral artery which results in formation of a vascular loop of varying size on the ventral surface of the spinal cord from C1 to C3 (Wiland, 1966). Reduction in the size of these vascular loop may contribute to the
variation of the position of the formation of the basilar artery and occasional presence of arterial loop near the origin of basilar artery as seen in slender loris and slow loris.

Another interesting feature of the arterial supply of the brain is the absence of both anterior inferior cerebellar and posterior inferior cerebellar arteries in slender loris. The position of these two arteries, however, could be located by the two branches which run in relation to VIII cranial nerve and XII cranial nerve. The former supplies the VII and VIII cranial nerves and choroid plexus of fourth ventricle while the latter one supplies the dorsal surface of the medulla which forms the floor of the IV ventricle. Both these branches fall short of supplying the cerebellum due to their small size. This deficiency is compensated by the superior cerebellar artery which runs on to the inferior surface of cerebellum to take over its supply.