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Morphological Configuration of the Brain Arterial Supply of the Goat *(Capra hircus)*

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Abstract
The anatomical study of the brain arteries is of great clinical and prognostic value. Because of veterinary practitioners have limited information about the intracranial circulation. Therefore, the present study aimed to configure course and variability of the arteries supplying the brain in goat. The study used eight goat heads to establishing the morphological pattern of the brain arteries. In goat, the internal carotid artery ill-developed supracranial but its intracranial reconstructed from the rete mirabile that formed from the maxillary artery at the cavernous sinus of dura mater. Our study recorded the brain received its blood through the maxillary and basilar arteries. The internal carotid artery leaved rete mirabile and divided into the rostral cerebral and caudal communicating arteries. The rostral cerebral artery formed the rostral part of the arterial circle of the brain while the caudal communicating arteries formed the caudal part. The rostral cerebral artery branched the rostral choroid artery, the artery of corpus callosum and bifurcated into the internal ophthalmic and internal ethmoidal arteries. The caudal communicating artery branched the caudal cerebral artery. The descend pattern of some arteries in all studied brains was asymmetric. The rostral cerebellar artery originated by double branches from the caudal communicating artery. The left caudal cerebellar artery was double while the right one was single.
Keywords: brain, arteries, goat

INTRODUCTION

Although many years have passed, arteries supplying the brain with blood have still attracted the attention in both human and animals. Knowledge of the routes of the arterial blood flow to the brain is important for examining the cerebrovascular diseases and interpretation of the neurologic signs [1].

The internal carotid, maxillary, and basilar arteries are the three potential blood supply to brain in mammals [1]. The ruminants lose the proximal two-thirds of its internal carotid [2]. The maxillary artery contributes significantly to the brain arterial circle through the rete epidural mirabile while the basilar artery attached to the arterial circle where its blood flow directed caudally rather than rostrally [3, 4]. The rete mirabile is a network of arteries supply the brain in ruminants; it formed from the intracranial carotid rete. The carotid rete is present within the cranial cavity replace the absent internal carotid artery where the maxillary artery forming a complex arterial network that converge to one carotid artery penetrate the dura mater to enter the brain [5, 6].

The role of the rete mirabile is to regulate the arterial blood flow toward the cerebrum as well as the thermal regulation of the brain preventing it from overheating; the blood after rete mirabile in the arterial circle was cooler than carotid arterial blood [7, 8]. In addition, the carotid rete mirabile has a flow- damping effect by keeping resistance to blood flow when a change in the caliber of the brain arteries occurs [9].

The intracranial surgery and chemotherapy are introduced in veterinary medicine. Variations of the rete mirabile, arteries branches and anastomosis need to considered before surgical and therapeutic approaches [1].

So, the present study was to define the arteries that supply and form the arterial circle of the brain in goat to compensate the lack of information on this particular subject as needed for clinicians.

MATERIALS AND METHODS

Eight head of Egyptian baladi goats of both sexes (four male and four female) of 1-3 aged and weighing about 20-30 kg used to the current study.

The local animal ethics review panel approved this protocol. This study followed the guidelines for the care and use of laboratory animals and the animal welfare and ethics committee of the Faculty of Veterinary Medicine, Alexandria University, Egypt.

The left and right common carotid arteries injected with latex colored with red carmine stain and the heads preserved within 10% formalin solution for two weeks. The brain removed outside the cranial cavity by sawing the skull manually 1 cm above the supraorbital margin rostrally and external occipital protuberance caudally. After opening of the skull, the dura opened and the brain detached by retracting the brain backwards and cutting the falx cerebri from its attachment to crista galli, olfactory nerves, optic nerve, internal carotid artery, occulomotor and trochlear nerves. The attached margin of tentorium cerebelli incised to remove of the brain stem and cerebellum intact with the cerebral hemispheres; the remaining cranial nerves cut. The intact brains after removed from the cranial cavity stored in formalin containers, after that the brains prepared, the course and variability of arteries investigated and recorded.

RESULTS

In goat, the main source of blood supply to the brain was from the maxillary and basilar arteries. Where, the internal carotid artery poorly developed in the young animals and its portion proximal to cranial cavity is absent in the adult animals. The maxillary artery formed a complex arterial network at the cavernous sinus of dura mater (Fig.1/1), the carotid rete mirabile that supply the blood to the brain arterial

circle through the internal carotid artery, which was the efferent artery emerged from the carotid rete toward the brain. Thereafter the internal carotid and basilar arteries formed the arterial circle that lied beneath the brain stem and took the heart shape.

In goat, the arterial circle was a circle, it formed by the junction of the rostral cerebral arteries rostrally and the caudal communicating arteries with the basilar artery caudally.

INTERNAL CAROTID ARTERY

It appeared on the base of the brain lateral to optic chiasm and bifurcated into the rostral cerebral artery (Fig.2/2) and caudal communicating artery (Fig.2/3).

ROSTRAL CEREBRAL ARTERY

It formed the anterior part of arterial circle of the brain. It gave off the middle cerebral artery (Fig.2/4) at the level of optic chiasm that curved toward the lateral fissure and divided into two cortical branches. After that, the rostral cerebral artery curved toward the rostral piriform lobe to give the rostral choroid artery (Fig.2/5).

The rostral cerebral artery ran forwards and medially to reach the longitudinal fissure where it communicated with the opposite rostral cerebral artery through a fine plexiform network of vessels. This network replaced the rostral communicating artery (Fig.3/1). The rostral cerebral artery passed along the longitudinal fissure and the medial olfactory tract toward the olfactory bulbs to give the marginal artery that divided into two cortical branches on the medial surface of the hemispheres. However, it descended on the dorsal surface of the hemispheres to give the artery of corpus callosum (Fig.3/2).

CAUDAL COMMUNICATING ARTERY

It was the caudal continuation of the internal carotid artery. It ran in a semicircle around the midbrain and join the similar vessel on the other side at the level of prepontian sulcus to form the basilar artery. The caudal communicating artery gave the caudal cerebral artery (Fig.2/6), caudal choroid artery (Fig.2/7) and rostral cerebellar artery (Fig.2/8).

BASILAR ARTERY

The basilar artery carried blood away from the arterial circle. It started at the prepontian sulcus (Fig.2/9) and ran caudally over the pons and the median fissure of the medulla oblongata. The basilar artery gave the pontine artery beyond the level of the abducent nerve (Fig.2/11), it gave the caudal cerebellar artery (Fig.2/10) and it gave many medulla oblongata branches (Fig.2/12). The diameter of the basilar artery gradually decreased caudally and continued as the ventral spinal artery (Fig.2/13).

VARIATIONS

The descend pattern of some arteries in all studied brains was asymmetric. The rostral cerebellar artery originated by double branches from the caudal communicating artery (Fig.4/arrow). The left caudal cerebellar artery was double while the right one was single (Fig.4/arrowhead).

DISCUSSION

The goat as most ruminants has an intracranial carotid rete (rete mirabile epidural) which is a blood vascular network supplying the brain while equine, canine, and human have not rete mirabile epidural where the internal carotid artery supplies the brain, as reported by [5].

The main vessels forming the arterial circle of the brain in goat are the internal carotid arteries whose supracranial section atrophied after birth as recorded by [10, 11] in goat. The intracranial section of the internal carotid artery reconstructed mainly from the rostral epidural rete mirabile which supplies the arterial circle, the basilar artery carry the blood caudal from the arterial circle, no vertebral blood reaches the brain as recorded by [2], [12] in sheep and goat, [13] in mammals, [6, 14] in pig. While [15, 16] in human, [17] in dog, [18] in donkey stated that the brain receives blood by both the internal carotid and the basilar arteries, this means blood supply to the forebrain originates mainly from the internal carotid artery while the caudal area of the brain supplied with vertebral artery. Whatever in cattle; Blood enters the arterial circle via maxillary and vertebral artery pathways, this means all areas of the brain supplied with blood from mixed maxillary and vertebral arterial origins and the basilar artery carries blood away from the arterial circle [2, 6] in ruminants, [19] in red deer, [13] in mammals, [20] in cattle. But in camel, the rete mirabile formed by the retial branches of the maxillary, external ophthalmic and the internal carotid arteries [21].

Our study recoded the arterial circle was complete in all studied animals because of the network of communicating vessels joined the two opposite rostral cerebral artery rostrally and the two caudal communicating arteries closed it caudally, similar finding noted by Brudnicki [22] in goat, Kürtül, Aslan [20] in cattle but Ashwini, Shubha [23] reported that the rostral communicating artery was a single artery in man. While Ozgel [17] in dog recoded that, it was incomplete because of the absence of the rostral communicating arteries.

Our study revealed that the internal carotid artery bifurcated into the rostral cerebral and caudal communicating arteries; similar finding recorded by Brudnicki [22] in goat, but Ozgel [17] in dog, Kapoor, Kak [13] in goat, Ashwini, Shubha [23] in man, cow, sheep, goat, pig noted the internal carotid artery divided into the rostral cerebral, middle cerebral and caudal communicating arteries.

Our result recorded a variability in the descend of the rostral and caudal cerebellar arteries from the caudal communicating artery and basilar artery, respectively, this is different to marked by Kapoor, Kak [13] in goat who recorded the rostral cerebellar artery is a branch of caudal cerebral artery.

The basilar artery, similarly to its course in other ruminants, it ran caudally showing a decrease in diameter. Vertebral arteries, similarly to other ruminants, not well developed, which suggests that their contribution to cerebral blood-supply remains inconsiderable a similar conclusion by Ghoshal and Khamas [6] in ruminants.

CONCLUSION

The brain of goat receives its blood from the internal carotid artery which is reconstructed from the rostral epidural rete mirabile that formed from the maxillary artery. No vertebral blood reaches the brain.

The arterial circle was complete because of the network of communicating vessels joined the two opposite rostral cerebral artery rostrally and the two caudal communicating arteries closed it caudally.

The course and variability of brain arteries in goat was limited, compared with those reported in other ruminants. A notable variation in the origin and descend of the rostral and caudal cerebellar arteries recorded.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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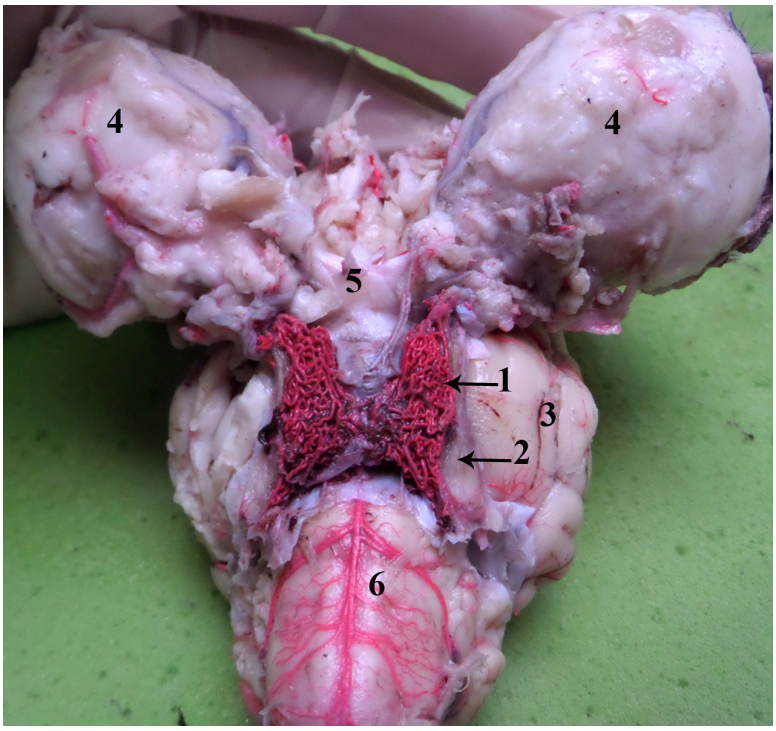

Fig.1. Ventral view of the brain showed the carotid rete mirabile. 1. Carotid rete. 2. Cerebral dura. 3 Cerebellum. 4. Eye ball. 5. Optic chiasm. 6. Medulla oblongata.

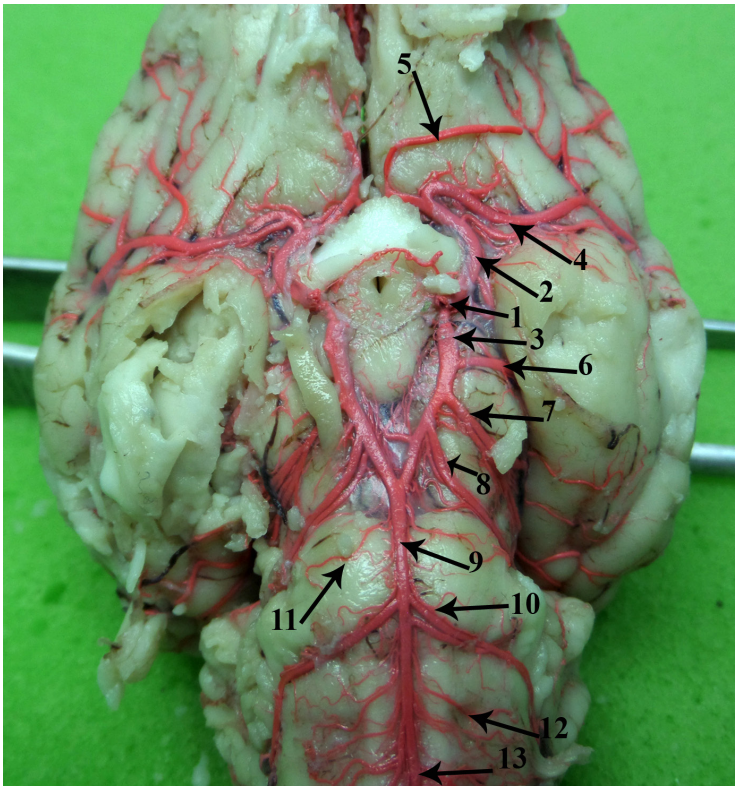

Fig.2. Ventral view showed the arterial circle of the brain. 1. Internal carotid artery. 2. Rostral cerebral artery. 3. Caudal communicating artery. 4. Middle cerebral artery. 5. Rostral choroid artery. 6. Caudal cerebral artery. 7. Caudal choroid artery. 8. Rostral cerebellar artery. 9. Basilar artery. 10. Caudal cerebellar artery. 11. Pontine artery. 12. Medulla oblongata branches. 13. Ventral spinal artery.

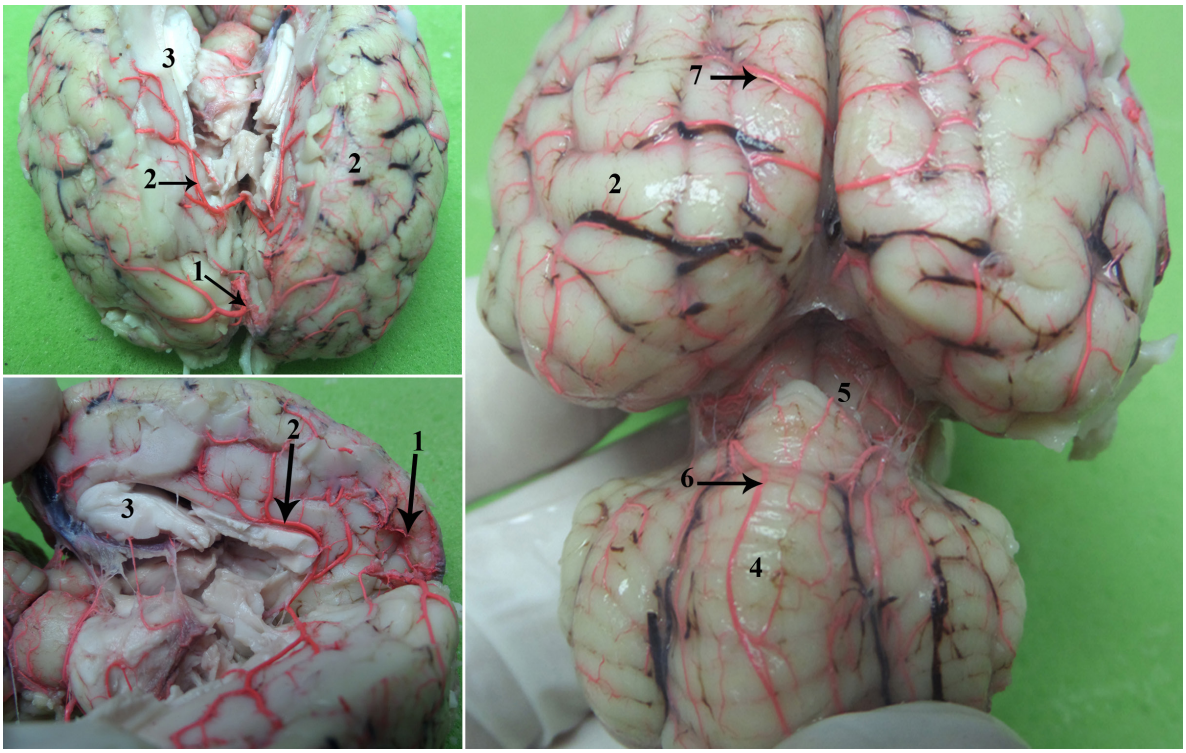

Fig.3. Dorsal view of the brain showed: 1. rostral cerebral artery communicating network. 2. Corpus callosum artery. 2. Cerebral hemisphere. 3. Corpus callosum. 4. Cerebellum. 5. Corpora quadrigemina. 6. Rostral cerebellar branches. 7. Rostral cerebral branches.

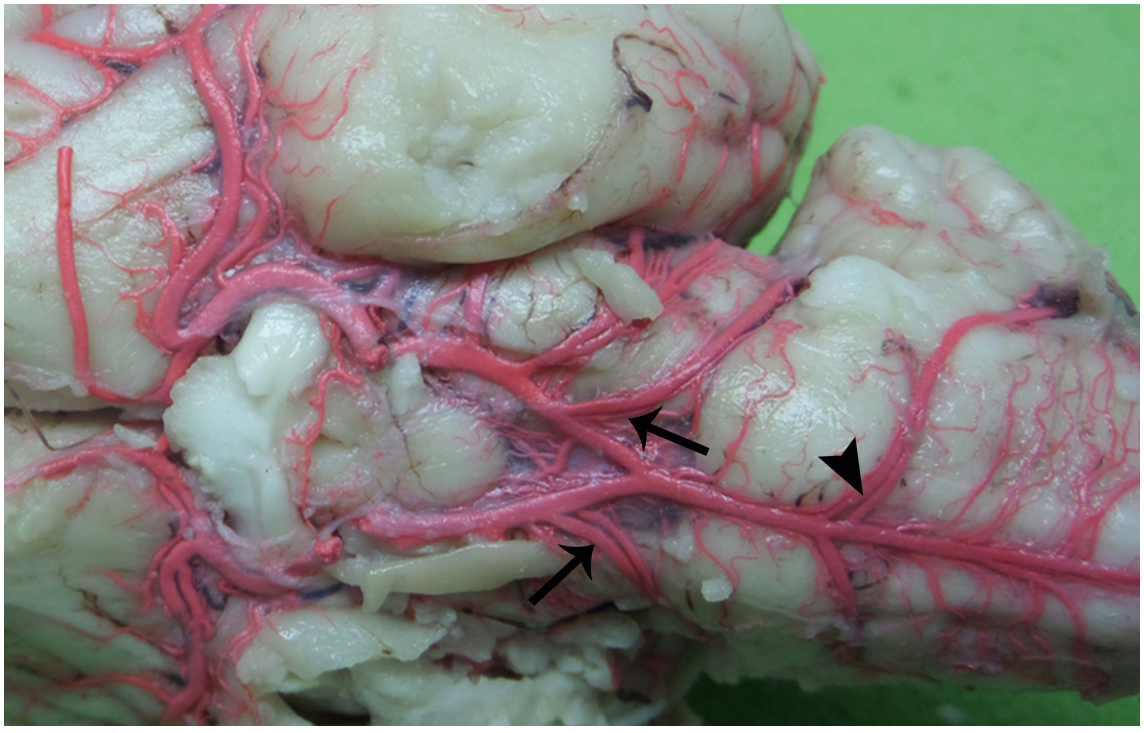

Fig.4. Ventrolateral view of the brain showed a double rostral cerebellar artery (arrow) and double left caudal cerebellar artery (arrowhead).

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