The morphology of circulus arteriosus cerebri in the red squirrel *(Sciurus vulgaris)*

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ABSTRACT: In this study, the circulus arteriosus cerebri of the squirrel was investigated. Ten squirrel were used. Coloured latex was given from left ventriculi of the all squirrels. Circulus arteriosus cerebri was examined after the dissection was made. The basilar artery was formed by merge of the right and left vertebral artery. The caudal communicans artery which was caudal part of circulus arteriosus cerebri was formed by the basilar artery on sulcus pontocrurale. From caudal to cranial, the branches originated from the basilar artery and circulus arteriosus cerebri to cerebrum and cerebellum were as follows: the caudal cerebelli artery,rami ad pontem, the rostral cerebelli artery, the caudal choroidea artery, the caudal cerebral artery, the internal ophtalmic artery, the rostral choroidea artery, the media cerebral artery, rami striati and the rostral cerebral artery. In squirrels a variability was observed in the branches that the rostral cerebral artery gives, and their endings. It was determined that the internal carotid artery didn't exist in 4 animals when the right and left vertebral artery were ligatured. It was found that the internal carotid artery didn't contribute to the arterial blood to circulus arteriosus cerebri and the arterial blood to circulus arteriosus cerebri of squirrels is provided via only the basilar artery.

Keywords: circulus arteriosus cerebri; brain; red squirrel (*Sciurus vulgaris*)

The rodents (*Rodentia*), which are the widest order of placental mammals, comprise more than half of the mammals actually known. The red squirrel is a representant of the Sciuridae family, which constitutes a group of the older *Rodentia* (Weichert, 1970; Kuru, 1987; Demirsoy, 1992). The circulus arteriosus cerebri has been studied in variety of mammals including dog (Miller et al., 1964), cat (McClure et al., 1973), rat (Brown, 1966; Green, 1968), rat and mouse (Firbas et al., 1973), mouse (Cook, 1965; Wiland, 1974), Guinae pig (Ocal and Ozer, 1992), Guinea pig and rabbit (Popesko et al., 1990), rabbit (Brehmer and Beleites, 1988), and porcupines (Aydin et al., 2005b). Formerly, immunohistochemical localization of calbindin-D28k in the kidney and cerebellum of the red squirrel was stuied by Aydin et al. (2005a) however to our knowledge, no study exists to investigate circulus arteriosus cerebri in the red squirrel (*Sciurus vulgaris*) thus, this is the first study on the circulus arteriosus cerebri of the squirrel. The purpose of this study was to document arteries that constitute the circulus arteriosus cerebri of the red squirrel (*Sciurus vulgaris*), and its morphological structure.

MATERIAL AND METHODS

Ten adult squirrel that hunted by the villagers in Eastern Anatolia were used. After animals were anesthized with penthatol (6 ml/kg), a plastic pipe 1cm diameter, and 5–10 cm in length was installed to the left ventriculi of animal' heart. After the blood content was drained, coloured latex was injected by hand to the left ventriculi through this pipe. In 4 out of 10 examined animals, to see whether the internal carotid artery was exist, the vertebral artery dexter and sinister were ligatureted when this application was performed. After a few days of fixation in 10% formalin, the skulls of squirrels were placed in 10% hydrochloric acid for 24 h for decalcification and the skulls were then easily opened. The arterial patterns at the base of the brain were

examined and pictured. For the terminology, the Nomina Anatomica Veterinaria (1994) was used.

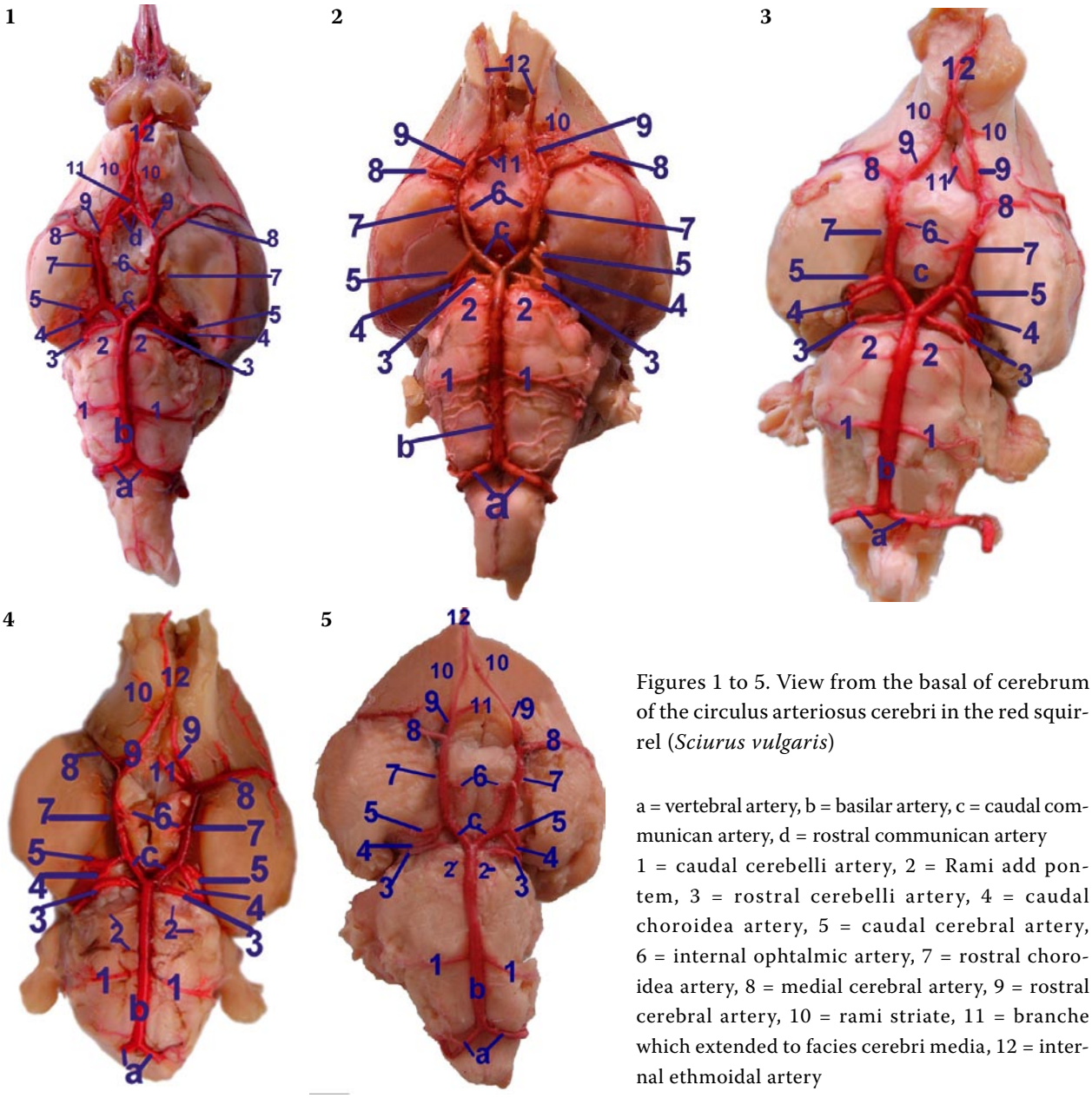
RESULTS

The basilar artery was formed by fusion of the right and left vertebral artery at the base of the joint point of the medulla oblongata and the medulla spinalis. The caudal communicans artery was formed by seperation of basilar artery into two branches on sulcus pontocrurale. In the front, the branches of the rostral cerebral artery, and their endings shamed a variability. Arteries which vascularise the cerebrum and cerebellum originated from the caudal communicans artery, basilar artery and rostral cerebral artery.

Arteries originating from the basilar artery

Medial cerebellar artery was not detected. The caudal cerebellar artery, which arose symmetrically, from the basilar artery dispersed to caudal part of cerebellum and ventriculus quartus. The small branches which was originated from the basilar artery dispersed through medulla oblongata.

Rami ad pontem seperating , some time symmetrically, some time asymmetrically from the basilar artery went to the pons.



Figures 1 to 5. View from the basal of cerebrum of the circulus arteriosus cerebri in the red squirrel (*Sciurus vulgaris*)

a = vertebral artery, b = basilar artery, c = caudal communican artery, d = rostral communican artery
1 = caudal cerebelli artery, 2 = Rami add pontem, 3 = rostral cerebelli artery, 4 = caudal choroidea artery, 5 = caudal cerebral artery, 6 = internal ophtalmic artery, 7 = rostral choroidea artery, 8 = medial cerebral artery, 9 = rostral cerebral artery, 10 = rami striate, 11 = branche which extended to facies cerebri media, 12 = internal ethmoidal artery

The rostral cerebelli artery which arose as symmetrically dispersed to caudal of tectum mesencephali and cranial of cerebellum.

Arteries originating from the caudal communicans artery

Caudale choroidea artery exhibited variability as originated from the caudal communicans artery. The caudale choroidea artery originated together with the caudal cerebral artery at the right side and directly at the left side in three out of five animals examined (Figures 2, 4, 5), directly at both right and left side in the one animal (Figure 3) , together with the caudal cerebral artery at both left and right side in the other animal (Figure 1). Then it divided into two branches at the join point of lateral part of tectum mesencephali and crus cerebri. The first branche dispersed to ventriculus tertius and tectum mesencephali and the second one dispersed to cranial part of the cerebellum and tectum mesencephali.

The caudal cerebral artery originated from the caudal communicans artery at cranial of the caudale choroidea artery, or together with it: After leaving the caudal communicans artery it gave branches to the cranial part of tectum mesencephali at caudo-ventral of the hemisferium and epitalamus and to ventriculus tertius. Same terminal branches of caudal cerebral artery merged with branches which originated from the rostral communicans artery or with the rostral cerebral artery sinister and dexter, at the caudal part of facies media cerebri in fissura longitudinalis cerebri.

The internal ophtalmic artery which originated as the thin branche from medial of the middle part of circulus arteriosus cerebri extends to orbita by passing through the sulcus chiasmaticus after giving one branche to hypophyse.

Arteries originating from the rostral cerebral artery

The rostral choroidea artery arose from the rostral cerebral artery extending under the lobus priformis gave branches to ventriculus laterale, hypcampus and cranial of the tectum mesencephalon.

The middle cerebral artery was the thickest branche which seperated from the middle part of the rostral cerebral artery as symmetrically. After it gave the branches to basal and lateral of foreport, middle and caudal partial of the hemisferium, it was seperated to cortical and central branches and terminated on the facies convexa cerebri.

The one branche which extended to facies media cerebri as arose from the rostral cerebral arteries, originated from the right rostral cerebral artery at two animals (Figures 2, 5), from left side (Figures 3, 4) in two out five animals examined, and it was originated from that both the rostral communicans artery and the left rostral cerebral artery in one animal (Figure 1) that had rostral communicans artery. This artery was merged with last branches of the caudal cerebral artery at the caudal part of facies media cerebri.

Rami striati had been distributed to gyrus olfactorius laterale

After the rami striati was given by the rostral cerebral arteries at the front side of circulus arteriosus cerebri, it joined to both the rostral communicans artery and the rostral cerebral artery sinister and dexter in the one animal (Figure 1), to only rostral cerebral artery sinister and dexter in two animals (Figures 3, 5), and it did not joined to anything in two animals (Figures 2, 4). The internal ethmoidal artery was constituted by to extensions of the right and left rostral cerebral artery after they joined to each other, and by their last parts when they didn't each other join to.

DISCUSSION

It was reported that the arterial blood to circulus arteriosus cerebri is provided by the basilar artery and the internal carotid artery in rat (Brown, 1966; Green, 1968), mouse (Cook, 1965; Wiland, 1974), rabbit (Barone et al., 1973; Brehmer and Beleites, 1988), cat (McClure et al., 1973; Getty, 1975), and dog (Miller et al., 1964; Getty, 1975), while it is formed by the internal ophtalmic artery, the basilar artery and the internal carotid artery in guinea pig (Ocal and Ozer, 1992), and it is formed by the only basilar artery in porcupine (Aydin et al., 2005b). We reported here that the arterial blood to circulus arteriosus cerebri of the squirrel (*Sciurus vulgaris*) resembles that of porcupine (Aydin et al., 2005b).

It was reported that the caudal cerebelli artery originated from the basilar artery as symmetrical in mouse (Wiland, 1974), dog and cat (Getty, 1975), and rabbit (Barone et al., 1973), and as asymmetrically in Guinea pig (Ocal and Ozer, 1992), dog

(Miller et al., 1964), cat (McClure et al., 1973). The caudal cerebelli artery of squirrel (*Sciurus vulgaris*) originated from the basilar artery as symmetrically, and its origin resembles that of mouse (Wiland, 1974), dog and cat (Getty, 1975), rabbit (Barone et al., 1973), and porcupine (Aydin et al., 2005b).

According to Wiland (1974), the medial cerebelli artery, originated as asymmetrically from the basilar artery, mostly single, but some times as two- three branches in mouse, and its terminal branches were edged with the last branches of the caudal cerebelli artery. İt originated as a symmetrical branche from the basilar artery in dog (Getty, 1975) and in porcupine (Aydin et al., 2005b). Getty (1975) reported that it exists as extension to the caudal cerebelli artery in cat. The squirrels did not exist the medial cerebelli artery.

Brown (1966) reported that the rostral cerebelli artery generally seperated from the basilar artery, some times one branche from the caudal communicans artery, the other branche as asymmetrically from the basilar artery in rat. İt is originated from the basilar artery (Popesko et al., 1990), or the caudal communicans artery in Guinea pig (Ocal and Ozer, 1992), and from the caudal communicans artery in mouse (Wiland, 1974), rabbit (Barone et al., 1973), dog (Miller et al., 1964), cat (McClure et al., 1973) and porcupine (Aydin et al., 2005b); According to Getty (1975), the rostral cerebelli artery is a branche of the mesencephalic artery which seperated from the caudal communicans artery in dog and cat. The results of the present study partly were similar to those of mouse (Wiland, 1974), rabbit (Barone et al., 1973), dog (Miller et al., 1964), cat (McClure et al., 1973) and porcupine (Aydin et al., 2005b), but not to other species.

Choroidea artery orignated from the internal carotid artery in the rat (Green, 1968), as a single branche from cranial part of circulus arteriosus cerebri in mouse (Wiland, 1974), from the medial cerebral artery in dog (Miller et al., 1964). Some authors reported a cranial choroidea artery in dog (Miller et al., 1964; Getty, 1975), and the caudal choroidea artery in cats (McClure et al., 1973; Getty, 1975). While it was reported that there was both cranial and the caudal choroidea arteries originated from circulus arteriosus cerebri in porcupine (Aydin et al., 2005b). Findings of this study differ from other reports as some variabilites were observed as the caudal choroidea artery originated from the caudal communicans artery but they are in accordance with report of Aydin et al (2005b) in which both cranial and the caudal choroidea arteries exist.

Caudal cerebral artery originates from the caudal communicans artery in the rat (Green, 1968), mouse (Wiland, 1974), Guinea pig (Popesko et al., 1990), rabbit (Barone et al., 1973; Popesko et al., 1990), and porcupine (Aydin et al., 2005b). This artery originated from the joint point of the caudal communican artery and the basilar artery in rat (Brown, 1966), and Guinea pig (Ocal and Ozer, 1992). The results of the present study were different from these reports as the caudal cerebral artery originated from the caudal communicans artery, sometimes alone and, sometimes together with the caudal choroidea artery in the squirrels.

It was reported that the internal ophtalmic artery is originited from the rostral cerebral artery in the dog (Miller et al., 1964; Getty, 1975), originating from the internal carotid artery in the rat (Green, 1968), and from the middle of medial part of circulus arteriosus cerebri in the porcupine (Aydin et al., 2005b). Ocal and Ozer (1992) reported that blood is supplied to brain by the internal ophtalmic artery. The internal ophtalmic artery of squirrels (*Sciurus vulgaris*) resembles that of porcupine (Aydin et al., 2005a) and differed from that of dog (Miller et al., 1964; Getty, 1975), Guinea pig (Ocal and Ozer, 1992), and rat (Green, 1968).

The middle cerebral artery originated from the internal carotid artery in the dog (Miller et al., 1964; Getty, 1975), as a single branche from circulus arteriosus cerebri in mouse (Cook, 1965; Wiland, 1974), Guinea pig (Ocal and Ozer, 1992), cat (McClure et al., 1973; Getty, 1975), and porcupine (Aydin et al., 2005b), as two seperate branches from circulus arteriosus cerebri in rat (Brown, 1966; Green, 1968; Firbas et al., 1973),and rabbit (Popesko et al., 1990), and mouse (Firbas et al., 1973). Findings of this study resembles that of mouse (Cook, 1965; Wiland, 1974), Guinea pig (Ocal and Ozer, 1992), cat (McClure et al., 1973; Getty, 1975), and porcupine (Aydin et al., 2005b).

It was reported that two rostral cerebral arteries joined each other sometimes with the single branche (rostral communicans artery) (Miller et al., 1964; Brown, 1966; Green, 1968; McClure et al., 1973; Wiland, 1974; Getty, 1975; Popesko et al., 1990; Ocal and Ozer, 1992; Aydin et al., 2005b) with two branches (Brown, 1966; McClure et al., 1973), or they do not joine (Brown, 1966). In our study, the rostral cerebral dexter and sinister artery sometimes were joined and sometimes not. The internal ethmoidal artery was constitute with its join at each other, or from its branches continue.

Rostral cerebral artery was reported to give two branches which dispersed between two hemispherium in dog (Miller et al., 1964), cat and dog (Getty, 1975), and rat (Brown, 1966). In addition, it was reported the last part of this branche anostomosed with the last part of the caudal cerebral artery between two hemispherium in rat (Green, 1968), and mouse (Wiland, 1974). Wheras according to Aydin et al. (2005b), the branches which originated from both right and left rostral cerebral artery and the rostral communicans artery was dispersed at through two hemispherium. In the current study differing from existing reports, the one branche which originated from some time the rostral cerebral sinister artery, and some time the rostral cerebral dexter artery and a branche originating from rostralis communican artery in an animal had been distributed between two hemispheres. And these branches were anostomosed with the last branches of the caudal cerebral artery at the caudal of the facies media cerebri.

In addition to the internal ethmoidal artery, it is known that the internal ophtalmic artery originated from the rostral cerebral artery as the last branche in dog and cat (Getty, 1975), and in dog (Miller et al., 1964). It is reported that the last branche of the rostral cerebral artery was the internal ethmoidal artery in rat (Brown, 1966), mouse (Wiland, 1974), and porcupine (Aydin et al., 2005b). Although the result of our study partly resembles that of rat (Brown, 1966), mouse (Wiland, 1974), but it differs from other species as ethmoidal artery was formed by joining of right and left rostral cerebral arteries.

In conclusion, cerebellum is vascularized by two branches in squirrels and the medial cerebelly artery was absent in this species. In vascularization of brain, the caudal choroidea artery was thicker than the cranial choroidea artery. Internal carotid artery was also absent. Variabilities were observed in joining of right and left rostral cerebral arteries at the cranial part of circulus arteriosus cerebri and in their endings. The origin of the caudal choroidea artery was also variable.

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