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Macro-Anatomical Investigation of the Cerebral Arterial Circle (Circle of Willis) in Red Fox (*Vulpes vulpes* Leunnoleus, 1758)

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Abstract: In the study, formation of the cerebral arterial circle in red fox commonly spotted in Anatolia was examined. Five red foxes, regardless of their sexes were used in the study. Latex injection method was applied to the materials. Internal carotid artery and basilar artery were observed to form of the circle of Willis, elliptical and sides low around hypophysis. It was determined that internal carotid artery was at the basal surface of brain and at the lateral region of chiasma opticums and at rostrolateral hypophysis and divided into left and right rostral cerebral artery, medial cerebral artery and caudal communicans artery. It was also established that basilar artery extends to rostral and gives off caudal cerebellar artery, labyrinth artery and rami ad pontom bilaterally.

Key words: Brain, cerebral arterial circle, internal carotid artery, red fox, *Vulpes vulpes Leunnoleus*, Anatolia

INTRODUCTION

It was reported that cerebral arterial circle which provides the arterial vascularization of brain is formed by internal carotid artery and basilar artery (Anderson and Kubicek, 1971; Majewska-Michalska, 1998; Nanda and Getty, 1975).

Rostral cerebral artery is the prolongation of internal carotid artery towards rostral. It was reported that in sheep and goat, rostral cerebral artery combine to form veining and this veining functions as rostral communicans artery and in dog, monkey and rabit when both rostral cerebral artery enter into fissura longitudinalis cerebri, they form medial cerebral artery and this vessel functions as rostral communicans artery (Kapoor *et al*., 2003).

It was reported that medial cerebral artery arises from rostral cerebral artery in red and ground squirrel (Aydin, 2008; Aydin *et al*., 2009) and in Pampas fox, it is the short rostral branch emanating from the lateral region of internal carotid artery (Depedrini and Campos, 2003).

In dog, left and right caudal communicans arteries are the branches of internal carotid artery running along in caudomedial direction and joins the last branches of basilar artery (Kurtul *et al*., 2002).

Studies were carried out on the structure of cerebral arterial circle in dog (Miller *et al*., 1964) in cattle (Kurtul *et al*., 2003) in humans, cow, sheep, goat and pig (Ashwini *et al*., 2008) in fox (Depedrini and Campos, 2003) in camel (Ocal *et al*., 1999) in hamster and rabbit (Popescu *et al*., 1990) in rabbit, in cat (McClure *et al*., 1973) in red squirrel (Aydin, 2008) and in ground squirrel (Aydin *et al*., 2009). But in literature review, no research on cerebral arterial circle in red fox commonly spotted in Anatolia was not found. This study aims at investigating the vessels macro anatomically which form cerebral arterial circle in red fox and arise from this formation.

MATERIALS AND METHODS

In the study carried out, regardless of their sexes, five adult red foxes were used (*Vulpes vulpes* Leunnoleus, 1758). Under deep anaesthesia through xylazine-ketamin combination, the chest cavities of the foxes were opened and apex of their hearts were cut off to drain the blood. As stated in literature, vessels were cleaned out by administering 0.9% of serum physiology through the aortae (Miller *et al*., 1964). Coloured latex (ZPG 582-G) was injected into the right and left common carotid artery. Materials were kept in 10% of formaldehyde solution at room temperature for 2-3 days for the latex to freeze. Then, dissections were carried out and the pictures were taken. Nomina Anatomica Veterinaria (NAV) was used in naming anatomical terms.

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RESULTS AND DISCUSSION

It was determined that cerebral arterial circle was formed by internal carotid artery and basilar artery around hypophysis, low on the sides, resembling an oval-shaped ring (Fig. 1).

It was observed that internal carotid artery is at the basal surface of brain, at the lateral of chiasma opticum and at the rostrolateral of the hypophysis and gives off rostral cerebral artery, medial cerebral artery and caudal communicans artery (Fig. 1).

It was established that rostral cerebral artery is the prolongation of internal carotid artery towards rostromedial and forms rostral communicans artery joining in front of chiasma opticum after giving off internal ophthalmic artery, rostral meningeal artery and internal ethmoidal artery bilaterally. It was also determined that rostral meningeal artery and internal ethmoidal artery at the right side arise from the common root and separate from each other after 1 cm (Fig. 1 and 2).

It was established that rostral communicans artery was formed by anastomosis of right and left rostral cerebral artery with each other and existed at the rostral of chiasma opticum and at the ventral part of fissura longitudinalis ventralis (Fig. 1 and 2).

It was established that separating from internal carotid artery bilaterally, medial cerebral artery, the thickest vessel, gives off small branches and distributes at the facies convexa of hemisferium cerebri by reaching fissura pseudosilvia through the rostral of lobus piriformis (Fig. 2).

It was observed that caudal communicans artery was the prolongation of internal carotid artery in caudomedial direction and joined the last branches of basilar artery in front of pons. This vessel was ascertained to shape the lateral and caudal part of circle of Willis ring. The vessel was established to give off caudal cerebral artery, rostral cerebellar artery and several small branches along its course in caudomedial direction (Fig. 1 and 3).

It was ascertained that caudal cerebral artery arises from caudal comunicans artery at the caudolateral of pituitary gland bilaterally. It was observed to run along at the lateral of thalamus in dorsocaudal direction following its origin and bifurcate into two main branches after nearly 0.3 cm. These branches were determined to provide the nourishment of the caudal part of hemispheres splitting into many small branches (Fig. 1 and 3).

It was observed that rostral cerebellar artery is the last vessel separating from the anastomosis of caudal communicans artery and basilar artery bilaterally at the caudal part of circle of Willis and distributes at the rostral part of mesensephalon and cerebellum by dividing into many small branches (Fig. 1 and 3).

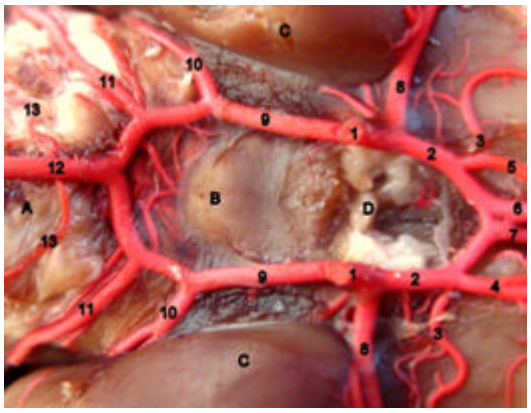

Fig. 1: Dorsal view of cerebral arterial circle: A: Pons, B: Corpus mamillare, C: Lobus piriformis, D: Chiasma opticum, 1: Internal carotid artery, 2: Rostral cerebral artery, 3: Internal ophthalmic artery, 4: Common trunk of rostral meningeal artery and internal ethmoidal artery, 5: Rostral meningeal artery, 6: Internal ethmoidal artery, 7: Rostral communicans artery, 8: Medial meningeal artery, 9: Caudal communicans artery, 10: Caudal cerebral artery, 11: Rostral cerebrallar artery, 12: Basilar artery, 13: Labrinth artery

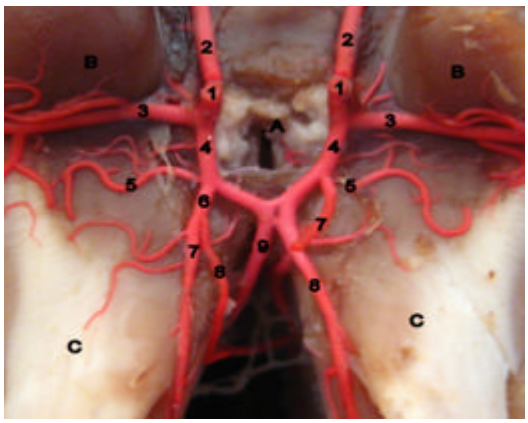

Fig. 2: Rostral view of cerebral arterial circle: 1: Internal carotid artery, 2: Caudal communicans artery, 3: Medial cerebral artery, 4: Rostral cerebral artery, 5: Internal ophthalmic artery, 6: Common trunk of rostral meningeal artery and internal ethmoidal artery, 7: Rostral meningeal artery, 8: Internal ethmoidal artery, 9: Rostral communicans artery, A: Chiasma opticum, B: Lobus piriformis, C: Bulbus olfactorius

It was established that basilar artery runs along towards the rostral at the basal surface of brain and gives

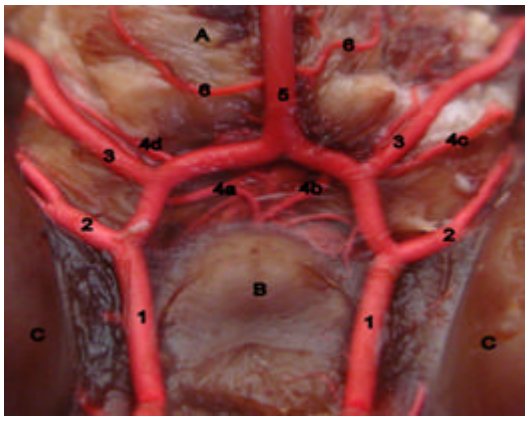

Fig. 3: Caudal view of cerebral arterial circle: 1: Caudal communicans artery, 2: Caudal cerebral artery, 3: Rostral cerebellar artery, 4a-d: Small branches of separating from anostomosis of basilar artery and caudal communicans artery, 5: Basilar artery, 6: Labrinth artery, A: Pons, B: Corpus mamillare, C: Lobus piriformis

off caudal cerebellar artery, labyrinth artery and rami ad pontom bilaterally. The vessel was observed to terminate joining caudal communicans artery at the meeting point of mesensephalon and pons (Fig. 1 and 3). It was reported that in cat (McClure *et al*., 1973), dog (Kapoor *et al*., 2003; Kurtul *et al*., 2002; Miller *et al*., 1964), goat (Brudnicki, 2000), mouse (Margaret and Cook, 1965; Wiland, 1974), rabbit (Barone *et al*., 1973; Kapoor *et al*., 2003) and rat (Brown, 1966; Green, 1968), cerebral arterial circle was formed by basilar artery and internal carotid artery in guinea pig (Ocal and Ozer, 1992) by internal ophthalmic artery, basilar artery and internal carotid artery in red and ground squirrel (Aydin, 2008; Aydin *et al*., 2009) only by basilar artery.

In this study, it was established that cerebral arterial circle in red fox was formed by internal carotid artery and basilar artery. In the study, it was found that circle of Willis was oval-shaped, sides low. It was not in agreement with the reports by Kurtul *et al*. (2002) indicating it to be in the shape of sphere in dogs, triangular in German-shephard breed with reports by Brudnicki (2000) and Kurtul *et al*. (2003) indicating it to be in the shape of 8 in goat and cattle foetuses.

Depedrini and Campos (2003) reported that in Pampas fox, rostral cerebral artery formed rostral communicans artery joining at fissura longitudinalis cerebri after giving off internal ethmoidal artery and internal ophthalmic artery. In addition to the reports of Depedrini and Campos (2003), it was also determined that the aforementioned vessel gave off rostral meningeal artery. It was observed that rostral meningeal artery had its origin from rostral cerebral artery from the common root with internal ethmoidal artery on the right side and had its origin as a separate branch on the left side.

Aydin (2008) red squirrel, Aydin *et al*. (2009) ground squirrel, Barone *et al*. (1973) rabbit, Green (1968) rat, Kurtul *et al*. (2002) dog, Popescu *et al*. (1990) rabbit and hamster and Wiland (1974) mouse reported that caudal cerebral artery had its origin from caudal communicans artery; Brown (1966) in rat, Ocal and Ozer (1992) hamster reported that it had its origin from the meeting point of caudal communicans artery and basilar artery. While the findings of the study were in agreement with the reports by Aydin (2008), Aydin *et al*. (2009), Barone *et al*. (1973), Green (1968), Kurtul *et al*. (2002), Popescu *et al*. (1990), Wiland (1974). They were not in agreement with the reports by Brown (1966) and Ocal and Ozer (1992).

Miller *et al*. (1964) reported that in dog internal ophthalmic artery had its origing from rostral cerebral artery; Green (1968) in rat from internal carotid artery; Aydin (2008) in red squirrel from the medial part of cerebral arterial circle. Aydin *et al*. (2009) reported that in ground squirrel the vessel was not joined to circle of Willis. As Miller *et al*. (1964) reported, it was established that the aforementioned vessel arose from rostral cerebral artery. It was not in agreement with the reports in literature (Aydin, 2008; Aydin *et al*., 2009; Green, 1968).

In the study carried out, it was established that right and left medial cerebellar artery had its origin symmetrically from basilar artery and this was in compliance with the reports by Depedrini and Campos (2003) on Pampas fox and Getty *et al*. (1975) on dog. But it was not in agreement with the report by Getty *et al*. (1975) that indicated the aforementioned vessel separated from caudal cerebellar artery in cat.

While Getty *et al*. (1975) reported that rostral cerebellar artery was the branch of mesencephalic artery springing from caudal communicans artery, it was determined in the study that the vessel arose from the caudal part of circle of Willis out of the anastomosis of caudal communicans artery and basilar artery.

De Vriese reported that the formation of circle of Willis was in three different shapes and further the type II was subdivided as α, β and γ. In the study, it was determined that the circle of Willis belonged basically to type II α and little to II β group.

CONCLUSION

In this study, the results are usually determined to be s imilar with literatures. However, there were some

differences in red fox such as circle of Willis resembling an oval shaped ring, a. meningea rostralis arose from a. cerebri rostralis and rostral cerebellar artery arose from the caudal part of circle of Willis out of the anastomosis of caudal communicans artery and basilar artery.

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