Slov Vet Res 2017; 54 (2): 83-9
UDC 636.09:611.813:612.133:599.744.121

Original Research Article

TELENCEPHALON VASCULARITY IN COMMON FOX (*Vulpes vulpes*)

Benedykt Skoczylas, Witold Brudnicki, Krzysztof Kirkiłło-Stacewicz*, Włodzimierz Nowicki, Jan Wach

UTP University of Science and Technology, Faculty of Animal Breeding and Biology, Department of Animal Morphology and Hunting, Bernardyńska 6, 85-029 Bydgoszcz, Poland

*Corresponding author, E-mail: krzysztof.stacewicz@o2.pl

Abstract: The studies of the vascularization of the cerebrum in common fox were performed on 80 cerebral hemispheres. It was found that the middle cerebral artery is the strongest vessel supplying blood to the cerebrum. The artery gets divided into ten permanent branches. Two olfactory arteries supply the region of the cerebrum located on the border between the old and the new cortex. The other eight are divided into three branches heading towards the frontal lobe of the brain, two branches heading towards parietal lobe and three temporal branches heading towards the temporal part, that supply the region of the new cortex. The frontal, parietal and temporal branches descended independently from the main trunk of the middle cerebral artery or formed a common trunk. Common trunks for respective groups of branches have been described as the rostral, dorsal and caudal middle cerebral artery. In 7.5% of cases there were two independent branches of the middle cerebral artery extending from the rostral cerebral artery.

Key words: brain arteries; common fox

Introduction

A review of the literature shows that the first information on the construction of the middle cerebral artery in various mammalian species can be found in the publication of Hofmann (1900). More detailed information on the construction of the middle cerebral artery and its branches in the dog were reported by Hebermehl (1973). In other predatory species similar studies were performed in mink (Brown, 1968) and in the raccoon dog (Brudnicki et al., 1994). So far, in the literature on brain blood flow in fox one may find publications on the construction of the brain base arteries (Wiland, 1967; Ozudogru et al., 2012). These authors mention that the middle cerebral artery is one of the vessels extending from the arterial circle of the brain.

There are publications that discuss in detail cortical branches of the middle cerebral artery. These issues were described in cat by Chadzypanagiotis (1975), the author gives nomenclature for the various branches of this artery. Structured descriptions of the construction and the course of the cortical branches of the middle cerebral artery in some predatory species were presented by Wiland (1991).

Received: 23 June 2016
Accepted for publication: 3 January 2017

In recent years there have been numerous studies that discuss the construction of the middle cerebral artery in various animal species. This applies to vessels that expand as a single branch, e.g. in porcupine (Aydin et al., 2005), red squirrel (Aydin, 2008), otter (Skoczylas et al., 2012) and multiple arteries occurring in the wild boar (Skoczylas and Wiland, 1999) and in the domestic pig (Skoczylas, 2000). These publications stated that the cortical branches of the middle cerebral artery come to the same areas of the telencephalon. The differences occur in the pattern of descent and division of respective cortical branches of the middle cerebral artery. The pattern of division of the middle cerebral artery is affected by how the species has been classified and the pattern of groove-coverage of the cortex. In mammals on the surface of the cortex there is a different pattern of sulci, which can affect the structure of the cortical branches of the middle cerebral artery (Brauer and Schober, 1970). Considering the discrepancy resulting from respective descriptions and considering new studies, one has decided to investigate the pattern, the division and variation of cortical branches of the middle cerebral artery in common fox and to compare the results with the data reported by other authors.

Material and methods

The research was performed on 40 brains in common fox, namely a total of 80 cerebral hemispheres received as a result of hunting in the region of Pomerania and Kujawy. The animal heads were cut off at the height of the 3rd – 4th cervical vertebrae. The arteries were filled with latex introduced with medical syringe into the common carotid artery. The heads were fixed in a 5% formalin solution and then decalcified in hydrochloric acid, the skull cavity was opened and brains were taken out. The cerebral hemispheres were photographed and the following were being described: the anatomy, the division pattern and the course of cortical branches of the middle cerebral artery.

Results

In common fox the blood is supplied to the brain with internal carotid arteries (Fig. 1-a) and vertebral arteries.

The internal carotid artery, having entered the skull cavity and penetrated the dura mater, bifurcates into the rostral cerebral artery (Fig. 1-b) and caudal communicating artery (Fig. 1-c) which, together with their symmetrical vessels form an arterial circle of the brain.

From the initial section of the rostral cerebral artery towards the cortex there separates the middle cerebral artery.

The middle cerebral artery is the strongest vessel supplying blood to the cerebrum. The initial section of the main trunk of the middle cerebral artery goes along the dorsal surface of the optic tract. Then the section gets bended around the piriform lobe and goes through its rostral margin. Further on it runs to the lateral olfactory sulcus and, having passed it, it gets divided. From the initial section of the main trunk of the middle cerebral artery there descend minor central branches supplying blood to olfactory tracts and the piriform lobe. The main trunk of the middle cerebral artery gets divided into a number of cortical branches which run to the specific region of the cerebral hemisphere, supplying blood to specific regions of the brain.

The first permanent branches of the middle cerebral artery which supply both the old and the new cortex are olfactory arteries.

The rostral olfactory artery (Fig. 1-1), having separated from the main trunk of the middle cerebral artery, runs to the rostral part of the lateral olfactory sulcus it can ascend into in various places. Its terminal branches can also appear again from under the lateral olfactory sulcus and then ascend under the cortex surface.

The caudal olfactory artery (Fig. 1-2) ascends into the caudal part of the lateral olfactory sulcus and its terminal branches supply the area of the cortex found under the sulcus.

The other branches of the middle cerebral artery supply the areas of the cortex over the lateral olfactory sulcus. On the cortex towards the frontal lobe there spread three thick branches. As the first one there separates the orbital branch (Fig. 1-3) which is located lowest and it goes towards the region of the Presylvian sulcus where its terminal branches reach the coronary sulcus.

The ventral frontal branch (Fig. 1-4) vascularizes the middle part of the frontal lobe. The vessel goes through the rostral external Sylvian sulcus and the rostral Suprasylvian sulcus towards the coronary sulcus it passes towards the fornix.

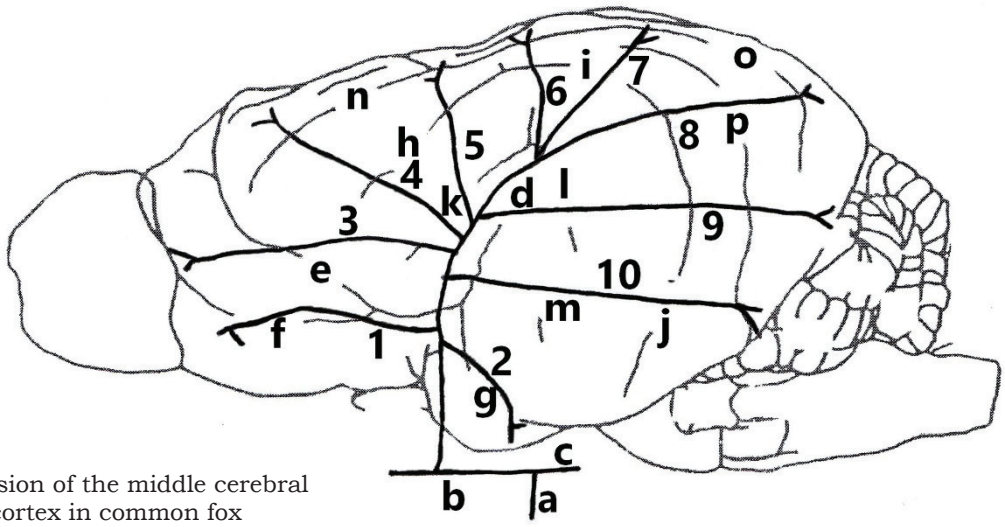

Figure 1: Diagram of the division of the middle cerebral artery on the surface of the cortex in common fox

1 – rostral olfactory artery, 2 – caudal olfactory artery, 3 – orbital branch, 4 – ventral frontal branch, 5 – dorsal frontal branch, 6 – rostral parietal branch, 7 – caudal parietal branch, 8 – dorsal temporal branch, 9 – middle temporal branch, 10 – ventral temporal branch, a – internal carotid artery, b – rostral cerebral artery, c- caudal communicating artery, d – Sylvian fissure, e – Presylvian sulcus, f – rostral lateral olfactory sulcus, g – caudal lateral olfactory sulcus, h – rostral Suprasylvian sulcus, i – middle Suprasylvian sulcus, j – caudal Suprasylvian sulcus, k – rostral external Sylvian sulcus, l – middle external Sylvian sulcus, m – caudal external Sylvian sulcus, n – coronary sulcus, o – marginal sulcus, p – external marginal sulcus

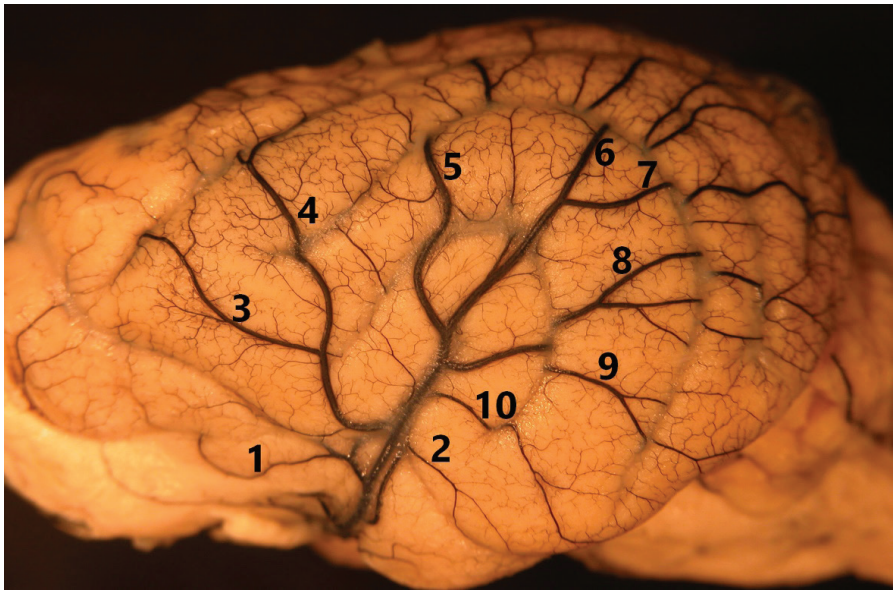

Figure 2: Independent departure of the caudal olfactory artery and the main trunk of the middle cerebral artery from the rostral cerebral artery

1 - rostral olfactory artery, 2 - caudal olfactory artery, 3 - orbital branch, 4 - ventral frontal branch, 5 - dorsal frontal branch, 6 - rostral parietal branch, 7 - caudal parietal branch, 8 - dorsal temporal branch, 9- middle temporal branch, 10 - ventral temporal branch

The dorsal frontal branch (Fig. 1-5), having separated from the middle cerebral artery at the height of the rostral external Sylvian sulcus, goes up to the region of the cruciate sulcus. The vessel supplies blood to the upper part of the medial surface of the frontal lobe.

The next vessel which runs towards the parietal lobe bifurcates into two branches.

The rostral parietal branch (Fig. 1-6) runs towards the middle external Sylvian sulcus to the marginal sulcus. The terminal twigs of that vessel supply blood to the area of the cortex found under the ansiform sulcus and run towards the middle edge of the cerebral hemisphere.

The caudal parietal branch (Fig. 1-7) also runs to the region of the marginal sulcus and further on it branches out into smaller vessels. Some of them ascend into the medial Suprasylvian sulcus and penetrate the hemisphere.

The lateral-caudal surface of the cerebral

hemisphere is supplied by the branches of the middle cerebral artery which descend from at various heights and they are referred to as temporal branches.

The dorsal temporal branch (Fig. 1-8) is usually the strongest cortical branch of the middle cerebral artery. Having left the Sylvian fissure, it runs towards the middle Suprasylvian sulcus and further to the upper margin of the cerebral hemisphere. The branch supplies blood to the upper part of the cortex.

The middle temporal branch (Fig. 1-9) descends a small distance away from the previous branch. The branches of that vessel spread towards the external marginal sulcus. Its terminal branches go onto the surface of the occipital lobe.

The ventral temporal branch (Fig. 1-10) runs to the end of the caudal external Sylvian sulcus. Having passed the caudal part of the sulcus, its branches spread towards the caudal Suprasylvian sulcus. Its terminal branches take part in the supply of a part of the occipital lobe.

Considering the general pattern of the spread the cortical branches of the middle cerebral artery in common fox, one shall note that respective sections of those branches can run inside respective sulci, always running towards the cortex areas described.

Analysing the pattern of descent of the cortical branches of the middle cerebral artery in the common fox individuals investigated, it was found that from the rostral cerebral artery on 76 (95%) cerebral hemispheres there descended a single independent vessel; the middle cerebral artery. Among them on 14 (17.5%) hemispheres from the main trunk there descended rostrally the independent rostral olfactory artery, then a common descend for orbital branch and the ventral and dorsal frontal branches. The main trunk, having ascended into the Sylvian fissure, on the surface of the cortex it showed a common trunk for rostral and caudal parietal branches as well as for the dorsal temporal branches.

In another 12 (15%) cases there descended rostrally from the main trunk an independent rostral olfactory artery and a common departure for the orbital, ventral and dorsal frontal branches. The main trunk got onto the surface of the cerebral cortex from the Sylvian fissure and formed a common descent for rostral and caudal parietal branches. Caudally from the main trunk of the middle cerebral artery, with a common trunk there separated the dorsal, middle and ventral temporal branches, whereas the caudal olfactory artery got separated independently from the main trunk of the middle cerebral artery.

On another 10 (12.5%) hemispheres from the main trunk the following separated rostrally with a common trunk: the orbital branch, the ventral frontal branch and the rostral olfactory artery. The main trunk, having ascended into the Sylvian fissure, on the surface of the cortex it showed a common trunk for dorsal frontal branch, rostral and caudal parietal branches. Caudally from the main trunk of the middle cerebral artery, with a common trunk there separated the dorsal, middle and ventral temporal branches and independent caudal olfactory artery.

On another 10 (12.5%) cerebral hemispheres from the main trunk the following separated rostrally with a common trunk: the orbital branch, the ventral and dorsal frontal branch and the rostral olfactory artery. Caudally from the main trunk the following separated with a common descent: the rostral and caudal parietal branches; dorsal, middle and caudal temporal branches as well as an independent caudal olfactory artery.

On another 8 (10%) cerebral hemispheres from the main trunk departed rostrally the common departure for the rostral olfactory artery and for the orbital branch, then a common departure for the ventral and dorsal frontal branches. Caudally from the main trunk there descended the common trunk for the ventral temporal branch and the caudal olfactory artery. The main trunk, having descended into the Sylvian fissure, got onto the surface of the cortex with a common descent for the dorsal frontal branch, rostral and caudal parietal branches as well as the middle and dorsal temporal branch.

On the other 8 (10%) hemispheres it was found that from the main trunk of the middle cerebral artery departed rostrally the rostral olfactory artery, the main trunk for the orbital branch and for the ventral frontal branch as well as the independent supeior frontal branch. The main trunk gave rostrally the independent caudal olfactory artery and having passed the lateral olfactory sulcus, it provided the common trunk for the ventral and the middle temporal branches. Having ascended into the Sylvian fissure, on the surface of the cortex it showed a common trunk for parietal branches and dorsal temporal branches.

On another 8 (10%) hemispheres from the main trunk of the middle cerebral artery separated

rostrally a common trunk for the olfactory artery and the orbital branch and the common decent for the interior and dorsal frontal branch. The main trunk gave caudally the caudal olfactory artery with a common departure for the ventral temporal branch. Having ascended into the Sylvian fissure, on the surface of the cortex it showed a common trunk for rostral and caudal parietal branches as well as the middle and dorsal temporal branch.

On yet another 6 (7.5%) cerebral hemispheres from the main trunk of the middle cerebral artery rostrally there separated, independently, the rostral olfactory artery, the orbital branch and the common departure for the ventral and dorsal frontal branch. Caudally from the main trunk the following separated with a common descent: the caudal olfactory artery and the ventral and the middle temporal branch. The main trunk of the middle cerebral artery, having got into the surface of the cortex, separated a common descent for rostral and caudal parietal branches and the dorsal temporal branch.

On the other 6 (7.5%) hemispheres it was found that from the rostral cerebral artery there bifurcated two independent branches of the middle cerebral artery. Among them in 2 (2.5%) cases the first independent branch from the rostral cerebral artery was the rostral olfactory artery, while the second branch from the rostral cerebral artery – the main trunk of the middle cerebral artery from which there descended rostrally independently: the orbital branch, the ventral and dorsal frontal branch. Caudally from the main trunk there separated an independent caudal olfactory artery and the common descent for the ventral and the middle temporal branch. The main trunk, having descended into the Sylvian fissure, got onto the surface of the cortex with a common descent for rostral and caudal parietal branches as well as the middle and dorsal temporal branch.

On yet another 2 (2.5%) cerebral hemispheres from the rostral cerebral artery there descended independently the caudal olfactory artery. Rostrally from the main trunk there separated an independent rostral olfactory artery and the common descent for the orbital branch and for ventral frontal branch and the independent dorsal frontal branch. Caudally from the main trunk there separated the independent ventral temporal branch. The main trunk, having ascended into the Sylvian fissure, got onto the cortex surface with the common descent for the middle and dorsal temporal branch and the common trunk for the rostral and caudal parietal branches (Fig.2).

Discussion

The middle cerebral artery supplies blood to the greatest region of the cerebrum. In the common fox the middle cerebral artery supplies the same areas of the brain as in the mammalian species studied so far. The discrepancies concern mostly its division into respective branches. Chadzypanagiotis (1975), describing the cortical branches in cat, differentiated between the branches supplying the old cortex, the branches on the border of the old and the new cortex as well as the branches for the new cortex. In the common fox the arteries supplying the old cortex are minor branches onto the piriform lobe and olfactory tracts. On the border of the old and the new cortex there are found the rostral and caudal olfactory arteries. In the common fox the rostral olfactory artery in 2.5% of the cases was a vessel which descended independently from the rostral cerebral artery. On the other cerebral hemispheres it was a vessel which got separated independently from the main trunk of the middle cerebral artery in 52.5% of the cases. In the other 22.5% cases the rostral olfactory artery was the vessel descending from the common trunk of the middle cerebral artery that gave rise to orbital branch and the ventral frontal branch. In another 12.5% of the cases the rostral olfactory artery descended with a common departure with the orbital branch, the ventral and dorsal frontal branch.

The caudal olfactory artery, on the other hand, in 5.0% of the cases was a vessel which descended independently from the rostral cerebral artery. On 50% hemispheres it was the vessel descending independently from the main trunk of the middle cerebral artery. In 20% of the cases the caudal olfactory artery separated with a common descent with the ventral temporal branch. In the other 25% hemispheres the caudal olfactory artery was one of the branches of a common trunk for the middle and ventral temporal branch.

The other cortical branches of the middle cerebral artery can be divided into a group of frontal, parietal and temporal branches. In the common fox, similarly as in other Carnivora species there occur eight main vessels which supply blood to the area of the new cortex of the cerebrum.

Besides, respective cortical branches can descend from the main trunk of the middle cerebral artery with a common descent. Such cases of descent were reported by Wiland (1991), Skoczylas et al. (2012) as the rostral, dorsal and caudal middle cerebral artery. In common fox the rostral middle cerebral artery has been presented as a common trunk for frontal branches and it occurred in 32.5% of the cases investigated, the dorsal middle cerebral artery was described as a common trunk for parietal branches, which was observed in 20% of the cases. The caudal middle cerebral artery as a common trunk for temporal branches was found in 27.5% of the cases.

In common fox the dorsal middle cerebral artery occurred as the lowest percentage of the cases, however, here the rostral middle cerebral artery dominated. Making a comparison of the present results with those reported by Wiland (1991), one can state that also in American otter the rostral middle cerebral artery was reported as the highest percentage of the cases. In common fox, similarly as in the other animal species studied, the parietal branches have developed poorest. On the surface of the cerebrum the best developed are the frontal branches of the middle cerebral artery.

From the description of the structure of the middle cerebral artery in the publications by Aydin et al. (2005), Aydin (2008), Skoczylas et al. (2012) in the porcupine, red squirrel and otter one can see that it is usually a single vessel descending from the rostral cerebral artery. The vessel, having passed the lateral olfactory sulcus, gets divided along its course into respective cortical branches. In the material investigated such a pattern of division of the middle cerebral artery was found in 92.5% of the cases. In common fox there were identified the cases of descent from the rostral cerebral artery of two independent arterial trunks in 7.5% of the cases. The second independent branch from the rostral cerebral artery was the rostral olfactory artery in 2.5% of the cases, the caudal olfactory artery –5 % of the cases and a common trunk of the rostral olfactory artery with the orbital branch in 2.5% of the cases. In other mammalian species the presence of two independent descents of the branches of the middle cerebral artery was found in wild rabbit (Brudnicki et al., 2012) in 36.5% of the cases, in raccoon dog (Brudnicki et al. 1994) in 18.5% of cases.

The present research show that observed in common fox the division of the middle cerebral artery into the same branches like in the other species investigated so far is a result of genetic limitations.

References

1. Aydin A. The morphology of circulus arteriosus cerebri in the red squirrel (*Sciurus vulgaris*). Vet Med 2008; 53 (5): 272–6.

2. Aydin A, Yilmaz S, Dinc G, et al. The morpholgy of circulus arteriosus cerebri in the porcupine (*Hystrix cristata*). Vet Med 2005; 50(3): 131–5.

3. Brauer K, Schaber W. Katalog der sangetiergehirne. Jena : VEB Gustav Fisher Verlag, 1970.

4. Brown JO. Some observations on the cerebral arterial circles in mink (*Mustela vison*). Anat Rec 1968; 196: 311–24.

5. Brudnicki W, Nowicki W, Skoczylas B, et al. Arteries of the brain in wild European rabbit *Oryctolagus cuniculus* (*Linnaeus, 1758*). Fol Biol 2012; 60 (3/4): 189–94.

6. Brudnicki W, Wiland C, Jabłoński R. Basilar arteries of the brain in raccoon dog (*Nyctereutes procyonoides Gray*). Arch Vet Pol 1994: 34 (1/2): 141–7.

7. Chadzypanagiotis D. Arteries on the surface of the cerebral hemisphere in the cat. Fol Morphol Warsaw 1975; 32: 385–99.

8. Hebermehl KH. Zur Topographie der Gehirngeafasse des Hundes. Anat Histol Embryol 1973; 2: 327–53.

9. Hofmann M. Zur vergleichenden Anatomie der Gehirn und Ruckenmarksarterien der Vertebraten. Z Morphol Anthropol 1900; 2: 247–320.

10. Ozudogru Z, Can M, Balkaya H. Macro-anatomical investigation of the cerebral arterial circle (Circle of Willis) in red fox (*Vulpes vulpes Leunnoleus, 1758*). J Anim Vet Adv 2012; 11(16): 2861–4.

11. Skoczylas B. Cortical branches of middle cerebral artery in domestic pig (*Sus scrofa f. domestica*). Electron J Polish Agric Univ Vet Med 2000; 3(1): e1 (6 pp.) http://www.ejpau.media.pl/volume3/issue1/veterinary/art-01.html

12. Skoczylas B, Brudnicki W, Nowicki W, et al. The cortical branches of the middle cerebral artery in the otter (*Lutra lutra*). Vet Med 2012; 57 (6): 282–6.

13. Skoczylas B, Wiland C. Cortical branches

of the middle cerebral artery in the wild boar (*Sus scrofa L.*) Electron J Pol Agric Univ Vet Med 1999; 2(1): e1 (6 pp.) http://www.ejpau.media.pl/volume2/issue1/veterinary/art-01.html

14. Wiland C. The arterial circle and basilar artery in fox. PTPN: papers of the Commission for Agricultural Science and Forest Sciences 1967; 23: 305–24.

15. Wiland C. Comparative studies of the cortical branches of the middle cerebral artery in carnivores (Carniviora). Zesz Nauk ATR Bydgoszcz 1991; 44: 1–52.

PREKRVAVLJENOST TELENCEFALONA PRI LISICI (*Vulpes vulpes*)

B. Skoczylas, W. Brudnicki, K. Kirkiłło-Stacewicz, W. Nowicki, J. Wach

Povzetek: Študije o prekrvavitvi možganov so bile opravljene na hemisferah 40 lisic. Ugotovljeno je bilo, da je srednja možganska arterija najmočnejša žila za dovod krvi v možgane. Arterija se razdeli na deset stalnih vej. Dve vohalni arteriji oskrbujeta področje v možganih, na meji med staro in novo skorjo. Drugih osem vej oskrbuje območje nove skorje: tri se razvejajo v smeri čelnega režnja, dve v smeri temenskega in tri v smeri senčnega režnja možganov. Čelne, temenske in senčne veje se spuščajo neodvisno od glavnega debla srednje možganske arterije ali pa oblikujejo skupno deblo. Skupna debla za posamezne skupine vej so bila opisana kot rostralna, dorzalna in kavdalna sredinska arterija. V 7,5 % primerov sta bili opaženi dve neodvisni veji srednje možganske arterije, ki se nadaljujeta od rostralne možganske arterije.

Ključne besede: možganske arterije; lisica