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Original Scientific Article

ARTERIAL SUPPLY OF THE CEREBRAL CORTEX IN CATTLE (*Bos primigenius f. dom.*)

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Summary: Studies of the vascularization of the cerebrum in cattle were performed on 60 cerebral hemispheres received from a meat-processing plant in Bydgoszcz, Poland. The sex of the cattle was not determined. It was found that the middle cerebral artery is the strongest vessel supplying blood to the cerebrum. The artery is 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 lobe, 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 the respective groups of branches have been described as the rostral, dorsal and caudal middle cerebral arteries. The present research show that the division of the middle cerebral artery into the same branches or their groups observed in cattle, like in the other mammalian species investigated thus far, is a result of genetic limitations.

Key words: brain arteries; cattle

Introduction

In the literature concerning telencephalon vascularity in cattle, Hofman (1900), Jenke (1919), Chomiak and Walento (1967) report on the anatomy and the variability of the brain base arteries, while Godynicki (1972) does so on the system of blood supply to the brain. In the literature, there seem to be no paper on the cortical branches of the middle cerebral artery in cattle, which is the main blood vessel supplying the cerebrum. There are publications in which authors describe the cortical branches of the middle cerebral artery; see Chadzypanagiotis (1975), Wiland (1991) on the cortical branches of some predatory species, Skoczylas and Wiland (1999) of wild boar.

Regarding biungulates, descriptions of the cortical branches of the middle cerebral artery in domestic pig (Walinczus, 1973), bison (Węgrzyn et al, 1983), roe deer (Jabłoński, Roskosz 1997), elk (Jabłoński et al, 1999), goat (Brudnicki et al, 2005) and in fallow deer (Skoczylas et al, 2011) have been made.

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It was found that the cortical branches of the middle cerebral artery in these species 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 the groove-coverage of the cortex. In mammals, there is a different pattern of sulci on the surface of the cortex, which can affect the structure of the cortical branches of the middle cerebral artery (Brauer, Schober 1970). Considering the discrepancy resulting from respective description and considering new studies, it was decided that the pattern, the division and variation of cortical branches of the middle cerebral artery in cattle should be investigated and the results compared with the data reported by other authors.

Materials and methods

The research was performed on 30 brains in cattle: a total of 60 cerebral hemispheres received from meat processing plant in Bydgoszcz. The sex of the samples was not determined. The animal heads were cut off at the height of the 3rd–4th cervical vertebrae. The arteries were filled with black latex introduced with medical syringe into the common carotid artery. The heads were fixed in a 5% formalin solution for 3 months, and then decalcified in hydrochloric acid; the skull cavity was opened and brains were removed. The cerebral hemispheres were photographed, and the following are described: the anatomy, the division pattern, and the course of cortical branches of the middle cerebral artery.

Results

In cattle, blood is supplied to the brain with internal carotid arteries. Its intracranial segment is regenerated from the rostral epidural rete mirabile. The extracranial section of the internal carotid artery undergoes atrophy after birth. Having passed the dura mater, the internal carotid artery (Fig. 1a) is divided into the rostral cerebral artery (Fig. 1b) and the caudal communicating artery that, together with the symmetrical vessels, form the arterial circle of the brain. At the height of the rostral border of the optic chiasma, the rostral cerebral artery gives off a thick arterial vessel: the middle cerebral artery (Fig. 1-Y, 2-Y). The middle cerebral artery is the most powerful vessel supplying blood to the telencephalon. The initial section of the main trunk of the middle cerebral artery runs along the ventral surface of the optic tract; the section then bends around the piriform lobe and runs in front of its rostral border. Further on, it runs towards the lateral rhinal sulcus and then, having passed it, it is divided. From the initial section of the main trunk of the middle cerebral artery, minor central branches supplying blood to olfactory tracts and the piriform lobe descend. The main trunk of the middle cerebral artery is divided into a number of cortical branches that run towards 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 towards the rostral part of

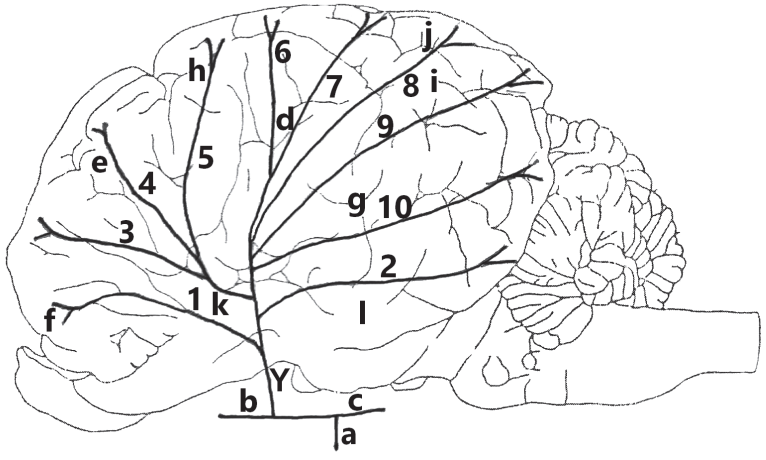

Figure 1: Diagram of the division of the middle cerebral artery on the surface of the cortex in cattle

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 – diagonal sulcus, f - Presylvian sulcus, g - caudal ectosylvian sulcus, h - middle Suprasylvian sulcus, i- caudal Suprasylvian sulcus, j - ectomarginal sulcus, k - rostral lateral rhinal sulcus, l - caudal lateral rhinal sulcus, Y - middle cerebral artery

the lateral rhinal sulcus and can descend into in various places. Its terminal branches can also appear again from under the lateral rhinal sulcus, and they ascend under the surface of the cortex.

The caudal olfactory artery (Fig. 1-2) ascends into the caudal part of the lateral rhinal sulcus, and its terminal branches also supply blood to the area of the cortex located over that sulcus. On the cortex, towards the frontal lobus, three thick branches spread.

The orbital branch descends first (Fig. 1-3); it supplies blood to the area of the cortex situated over the presylvian sulcus and below the diagonal sulcus. Its terminal branches reach the coronary sulcus.

The ventral frontal branch (Fig. 1-4) runs towards the diagonal sulcus, and then one of its branches ascends into that sulcus; the others spread on the surface of the cortex between the ansiform sulcus and the middle suprasylvian sulcus.

The dorsal frontal branch (Fig. 1-5), having descended from the main trunk of the middle cerebral artery, ascends into the initial section of the middle suprasylvian sulcus. Its terminal branches supply blood to the upper part of the medial surface of the frontal lobus.

Another vessel that runs towards the parietal lobus, ascending to the Sylvian fissure onto the surface of the cortex; after a short course, it bifurcates into two branches.

The rostral parietal branch (Fig. 1-6) and caudal parietal branch (Fig. 1-7) run towards the middle suprasylvian sulcus. Having passed the sulcus, the vessels spread medially, reaching the marginal sulcus. The lateral-caudal surface of the hemisphere is supplied by the branches of the middle cerebral artery, which descend at various heights; they have been referred to as temporal branches.

The dorsal temporal branch (Fig. 1-8), having descended from the Sylvian fissure, goes towards the caudal suprasylvian sulcus. Then, having passed the marginal sulcus, its terminal branches reach the internal marginal sulcus. They do not cross any more.

The middle temporal branch (Fig. 1-9) descends in a short distance from the dorsal temporal branch; it runs over the caudal ectosylvian sulcus. The terminal branches run towards the terminal section of the caudal suprasylvian sulcus and arrive on the surface of the occipital lobus.

The ventral temporal branch (Fig. 1-10), having separated from the main trunk of the middle cerebral artery on the surface of the cortex, supplies blood to the area between the lateral rhinal sulcus and the caudal ectosylvian sulcus. Its terminal branches participate in the supply of a part of the occipital lobus.

Considering the presented general pattern of the distribution of cortical branches of the middle cerebral artery, it should be noted that respective sections of those branches can be located inside respective sulci, sometimes undergoing further divisions, but always going in the direction of the area of the cortex described.

Factoring in the pattern of descent of cortical branches of the middle cerebral artery in the individual cattle , it was found that one independent vessel descended in all the cases from the rostral cerebral artery: the middle cerebral artery. Among them, on 6 (10.0%) hemispheres from the main trunk of the middle cerebral artery, a common trunk descended rostrally for the rostral olfactory artery, for the orbital branch, and for the ventral and dorsal frontal branches. The main trunk caudally separated an independent caudal olfactory artery with a common descent for the ventral and the middle temporal branches. The main trunk, having ascended into the Sylvian fissure, brought a common descent for the dorsal temporal branch and parietal branches onto the surface of the cortex.

In 6 (10.0%) cases, an independent rostral olfactory artery descended rostrally from the main trunk, followed by a common descent for the orbital branch and for ventral frontal branch. Caudally, from the main trunk of the middle cerebral artery, the common departure for the middle, ventral and dorsal temporal branches separated as well as for the caudal olfactory artery. The main trunk, having ascended into the Sylvian fissure, brought a common descent for rostral and caudal parietal branches as well as the dorsal temporal branch into the surface of the cortex.

On another 9 (15.0%) hemispheres, the independent rostral olfactory artery separated rostrally from the main trunk of the middle cerebral artery, followed by a common descent for the orbital branch and the ventral frontal branch. Caudally, from the main trunk of the middle cerebral artery, the independent caudal olfactory artery and the common departure for the ventral, middle and dorsal temporal branches separated.

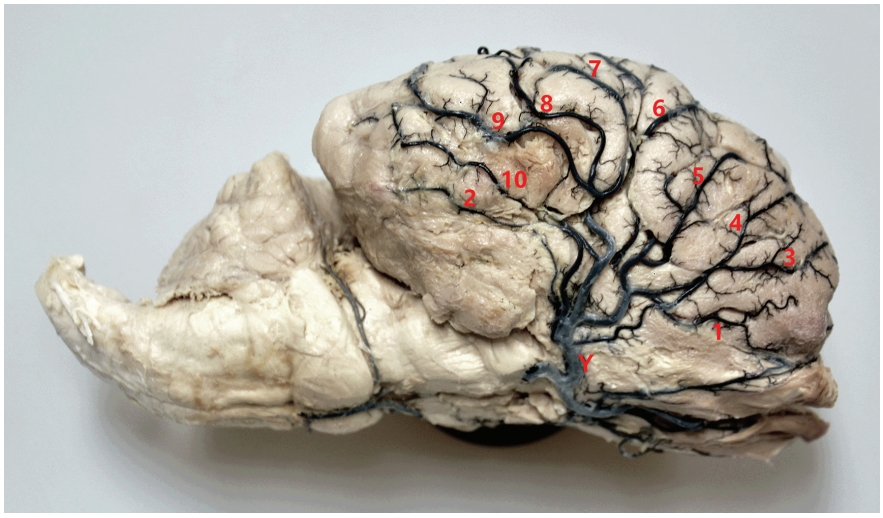

Figure 2: A single trunk of the middle cerebral artery that give rise to the specific cortical branches

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

The main trunk, having ascended into the Sylvian fissure, brought a common descent for the dorsal frontal branch as well as the rostral and caudal parietal branches.

On 3 (5.0%) hemispheres rostrally from the main trunk of the middle cerebral artery, the rostral olfactoral artery descended independently, then the common trunk for the orbital branch as well as the ventral and dorsal frontal branch. Caudally from the main trunk, with a common descent, the ventral and the middle temporal branches separated as did the caudal olfactory artery. The main trunk, having ascended into the Sylvian fissure, brought a common descent for the dorsal temporal branch and for the rostral and caudal parietal branches onto the surface of the cortex.

In 6 (10.0%) cases, the independent caudal olfactory artery and a common trunk for the orbital branch rostrally descended, followed by a common descent for rostral and caudal parietal branches. Having ascended into the Sylvian fissure, a common trunk for rostral and caudal parietal branches came to the surface of the cortex. Caudally from the main trunk of the middle cerebral artery, with a common descent, the ventral, dorsal and the middle temporal branches separated, while the caudal olfactory artery descended independently from the main trunk of the middle cerebral artery.

In the other 9 (15%) hemispheres, from the main trunk, rostrally with a common departure the orbital branch, the ventral frontal branch and the rostral olfactory artery descended. The main trunk of the middle cerebral artery caudally separated the dorsal frontal branch with a common descent for rostral and caudal parietal branches as well as the dorsal, middle and ventral temporal branches. The caudal olfactory artery descended independently from the main trunk of the middle cerebral artery.

In another 6 (10%) cases, a common departure for the caudal olfactory artery, the orbital branch, and the ventral frontal branch descended rostrally. The caudal bifurcation was a common trunk for the ventral temporal branch and the caudal olfactory artery. The main trunk came to the surface of the cerebral cortex from the Sylvian fissure and formed a common descent for the dorsal frontal branch, rostral and caudal parietal branches, as well as the dorsal and middle temporal branches.

In another 9 (15%) cases, 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, the following separated with a common descent from the main trunk of the middle cerebral artery: the rostral and caudal parietal branches; the ventral, dorsal and the middle temporal branches, while the caudal olfactory artery descended independently from the main trunk of the middle cerebral artery.

On another 3 (5%) cerebral hemispheres, the common trunk for the rostral olfactory artery and for the orbital branch departed rostrally from the main trunk of the middle cerebral artery, followed by a common departure for the ventral and dorsal frontal branches. Caudally from the main trunk, the ventral olfactory artery descended through the common trunk with the ventral temporal branch. The main trunk, having descended into the

Sylvian fissure, came to the surface of the cortex with a common descent for the rostral and caudal parietal branches as well as the middle and dorsal temporal branch.

In another 3 (5%) cases, an independent rostral olfactory artery and a common trunk descended rostrally for the orbital branch as well as the interior and dorsal frontal branches. Caudally from the main trunk of the middle cerebral artery, the caudal olfactory artery descended through the common trunk with the ventral temporal branch and a common trunk for the middle and dorsal temporal branches. The main trunk, having descended into the Sylvian fissure, came to the surface of the cortex with a common descent for the rostral and caudal parietal branches (Fig. 2).

Discussion

In cattle, the middle cerebral artery supplies the same areas of the brain as in the mammalian species studied thus far. The discrepancies concern mostly its division into respective branches. Chadzypanagiotis (1975), describing the cortical branches in cats, 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 cattle, 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 cortices, the rostral and caudal olfactory arteries are found. In cattle, in 45% of the cases, the rostral olfactory artery was a vessel that descended independently from the rostral cerebral artery. In 5% of the cases, a common descent with the orbital branch was demonstrated. On 25% of the cerebral hemispheres, one of the branches descended from the common trunk of the middle cerebral artery, which gave rise to the orbital branch and the ventral frontal branch. In the other 25% of the hemispheres, the rostral olfactory artery demonstrated a common descent with the orbital branch as well as the ventral and dorsal frontal branches.

The caudal olfactory artery, in contrast, was a vessel that descended independently from the main trunk of the middle cerebral artery in 55% of the cases. In 20% of the cases, the caudal olfactory artery separated with a common descent with the ventral temporal branch. On 15% of the cerebral hemispheres, it was one of the branches descending from the common trunk of the middle cerebral artery, which gave rise to the middle and dorsal temporal branches. In another 10% of the cases, it was one of the branches of the common trunk for the ventral, middle and dorsal temporal branches. The other cortical branches of the middle cerebral artery can be divided into a group of frontal, parietal and temporal branches. In cattle, similarly as in other Ruminantia species, there are eight main vessels that supply blood to the area of the new cortex of the cerebrum. Moreover, 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 arteries. In cattle, the rostral middle cerebral artery has been presented as a common trunk for frontal branches in 20% of the cases investigated; the dorsal middle cerebral artery was described as a common trunk for parietal branches, which was observed in 15% of the cases. The caudal middle cerebral artery as a common trunk for temporal branches was found in 25% of the cases.

In cattle, the dorsal middle cerebral artery occurred as the lowest percentage of the cases; however, in these cases the caudal middle cerebral artery dominated. Making a comparison of the present results with those reported by Skoczylas et al. (2012) in otters, it can be stated that the dorsal middle cerebral artery was reported in the lowest percentage of the cases. In cattle, similarly as in the other Artiodactyla, the parietal branches have developed the poorest. On the surface of the cerebrum, the temporal branches of the middle cerebral artery are the best developed.

From the description of the structure of the middle cerebral artery in the publications by Jabłoński and Roskosz (1997), Brudnicki et al. (2005), Skoczylas et al. (2011) in roe deer, goat and fallow deer, respectively, usually a single vessel descending from the rostral cerebral artery can be observed. The vessel, having passed the lateral rhinal sulcus, is divided along its course into respective branches and its main trunk heads towards the fornix. In the material investigated, such a pattern of division of the middle cerebral artery was found in 100% of the cases.

This research shows that the division of the middle cerebral artery into the same branches or their groups, observed in cattle, is a result of genetic limitations, as in the other mammalian species investigated thus far (Wiland, 1980).

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ARTERIJSKA OSKRBA MOŽGANSKE SKORJE PRİ GOVEDU (*Bos primigenius f. dom.*)

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Povzetek: Študije prekrvavitve možganov pri govedu so bile izvedene na 60 možganskih hemisferah, prejetih iz mesnopredelovalnega obrata v Bydgoszczu na Poljskem. Spol živine ni bil določen oziroma upoštevan. V raziskavi je bilo ugotovljeno, da je srednja cerebralna arterija najmočnejša žila, pomembna pri dovajanju krvi v možgane. Arterija je razdeljena na deset stalnih vej. Dve vohalni arteriji oskrbujeta področje v možganih na meji med staro in novo skorjo. Ostalih osem arterij je razdeljenih v tri veje, ki se nadaljujejo v smeri proti prednjemu režnju možganov, dve veji sta usmerjeni proti parietalnemu režnju, tri senčnične veje pa proti senčnemu režnju, ki oskrbuje področje nove skorje. Prednja, parietalna in senčnična veja se spustijo neodvisno od glavnega debla srednje možganske arterije ali pa oblikujejo skupno deblo. Skupna debla za posamezne omenjene skupine vej so bila opisana kot rostralne, dorzalne in kavdalne srednje možganske arterije. Pričujoča raziskava kaže, da je delitev srednje možganske arterije v iste veje ali njihove skupine, opažena pri govedu, tako kot tudi pri drugih doslej raziskanih vrstah sesalcev posledica genetskih omejitev.

Ključne besede: možganske arterije; govedo