

The cortical branches of the middle cerebral artery in the otter (*Lutra lutra*)

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ABSTRACT: The cortical branches of the middle cerebral artery in the otter were described using 60 hemispheres. It was demonstrated that the artery is divided into ten permanent branches. Two rhinal arteries supply the region of the brain located on the border between the old and the archicortex and the neocortex. The other eight branches are divided into three branches running towards the frontal lobe, two branches – to the region of the parietal lobe and three temporal branches which supply blood to the neocortex only. The frontal, parietal and temporal branches descended independently from the main trunk of the middle cerebral artery or first formed a common trunk. Common trunks for specific groups of bifurcations were described as the middle cerebral artery (anterior, superior and posterior).

Keywords: cerebral arteries; otter

The first data on the anatomical arrangement of the middle cerebral artery in various mammalian species were reported by Hofmann (1900). More detailed data on the middle cerebral artery and its branches in the dog was provided by Habermehl (1973); the author covered the arrangement of the artery and discussed the topography of its branches on the surface of the cerebral hemisphere but provided no description of its variability.

Detailed reports regarding the branches of the middle cerebral artery can be found in the literature. Chadzypanagiotis (1975) described the arrangement of the middle cerebral artery in the cat, and included the nomenclature of its particular cortical branches. Walinczus (1973) considered the range and the pattern of blood supply to particular regions of the telencephalon in the pig.

A systematised description of the structure and the pattern of the cortical branches of the middle cerebral artery in some species of carnivores were provided by Wiland (1991). Recently, numerous reports have centred on an investigation into the structure of the middle cerebral artery in various mammalian species. It has been demonstrated that particular regions of the brain are supplied by the

same arterial branches; single branches in the grivet (Jablonski et al. 2005), multiple branches in the wild boar (Skoczylas and Wiland 1999) and domestic pig (Skoczylas 2000).

Considering the published reports, one may conclude that the pattern of the division of the middle cerebral artery is affected by different factors, including systematic nomenclature and the arrangement of furrows on the cerebral cortex. In mammals there is a different arrangement of furrows and gyri on the surface of the cerebral cortex, which can affect the structure of the cortical branches of the middle cerebral artery (Brauer and Schaber 1970).

With these differences in mind, we here report an investigation into the course, division and variation in the cortical branches of the middle cerebral artery in the otter and compare our results with those available in the literature.

MATERIAL AND METHODS

These studies into the middle cerebral artery were carried out on 30 otter brains (60 cerebral hemispheres). The otter is a protected species and the

animals use in this study died in accidents, mostly as a result of becoming entangled in fishing nets, in the Kujawy and Pomorze Provinces. To begin, the heads were cut off at the height of the 3rd and 4th cervical vertebrae. Having prepared the common carotid arteries, one of the arteries was filled with black latex using a syringe. The heads were then fixed in a 5% formalin solution for three months and then, once the muscles were removed, the bones were decalcified in 5% hydrochloride acid. To bleach the brains and to remove all the blood clots from the venous vessels, brains were fixed in 2% hydrogen peroxide. The hemispheres were photographed and described, considering the structure, division and the course of the cortical branches of the middle cerebral artery.

RESULTS

The brain in the otter is supplied with blood by the internal carotid arteries (Figure 1-a) and vertebral arteries. The internal carotid artery, having perforated into the cranial cavity and dura mater, splits into the rostral cerebral artery (Figure 1-b) and the caudal communicating artery (Figure 1-c) which, together with the other-side vessels, forms the arterial circle of the brain. There was also observed a middle cerebral artery (Figure 1-d) separating from the initial part of the rostral cerebral artery towards the cerebral cortex.

The middle cerebral artery is the strongest vessel that provides the telencephalon with blood. The initial part of the main trunk of the middle cerebral artery goes along the ventral surface of the optic tract and in front of the anterior edge of the

piriform lobe, after which this part bends around the piriform lobe. Having gone through its rostral edge, it runs towards the lateral sulcus and, having passed it, it then divides. From the initial part of the main trunk of the middle cerebral artery there descend minor central vessels supplying blood to the olfactory tracts and the piriform lobe.

The main trunk of the middle cerebral artery is divided into a number of cortical branches which lead to the proper region of the cerebral hemisphere supplying blood to specific parts of the brain.

The first permanent branches of the middle cerebral artery which supply both the archicortex and the neocortex are olfactory arteries. Having branched out from the main trunk of the middle cerebral artery, the anterior olfactory artery (Figure 2-1) runs towards the rostral part of the lateral rhinal sulcus and it can penetrate it in various places. Its terminal branches can also emerge again from under the lateral rhinal sulcus and disappear into the cortex above the sulcus.

The posterior olfactory artery (Figure 2-2), similarly to the anterior vessel, penetrates the caudal part of the lateral rhinal sulcus in various places. Its terminal branches supply blood to the region of the cortex found above the sulcus.

Other vascular branches supply blood to the regions of the cerebral cortex above the lateral rhinal sulcus. These vessels run towards the specific regions of the cerebral cortex and enter into some furrows along their path before running further on the surface of the gyri towards the next system of sulci.

On the cortex, towards the frontal lobe, three thick branches are found. The first descent is the orbital branch (Figure 2-3) which runs towards the

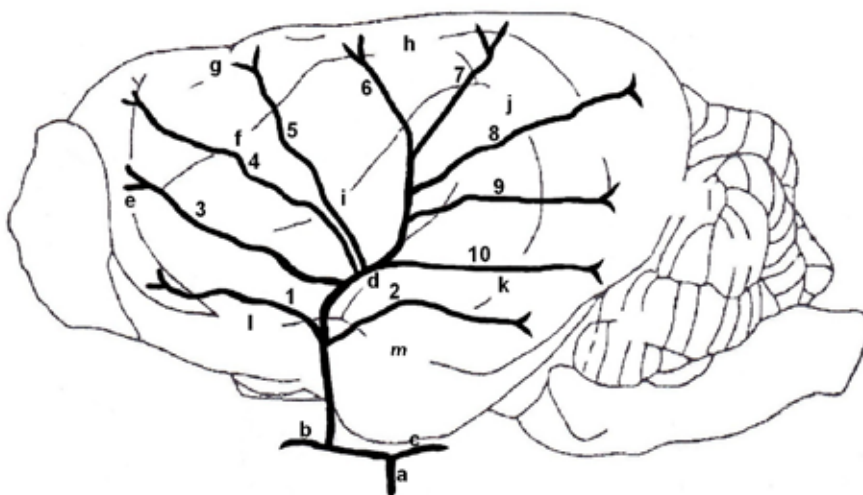


Figure 1. The division of the middle cerebral artery on the surface of the cortex in the otter



Figure 2. Departure of the single trunk of the middle cerebral artery from the rostral cerebral artery with all the cortical branches

region of the presylvian sulcus, where its terminal branches reach the coronary groove.

The inferior frontal branch (Figure 2-4) supplies the middle part of that region of the cortex; the branches of this vessel run through the rostral suprasylvian sulcus towards the coronary groove and pass it towards the vault. The superior frontal branch (Figure 1-5), having separated from the middle cerebral artery, goes upwards to the area of the cruciform sulcus and gives off smaller vessels which supply blood to the upper part of the medial surface of the frontal lobe.

The next vessel, running towards the parietal lobe, is bifurcated. The anterior parietal branch (Figure 1-6) runs towards the marginal sulcus and gives off smaller branches. The marginal branches of this vessel supply the area beyond the ansiform sulcus and run in the medial direction of the cerebral hemisphere.

The posterior parietal branch (Figure 1-7) also runs towards the marginal sulcus and gives off smaller vessels; some of the vessels enter the medial suprasylvian sulcus.

The lateral posterior surface of the hemisphere is supplied by the branches of the middle cerebral artery which depart successively at different heights and, as such, they have been referred to as temporal branches.

The superior temporal branch (Figure 1-8) is, as usual, the strongest cortical branch of the middle cerebral artery, with its prolongation in the cerebral cortex area. Having departed from the Sylvian fissure, it goes towards the upper edge of the cerebral hemisphere. The branch supplies blood to the upper part of the cerebral cortex.

The middle temporal branch (Figure 1-9) departs at a short distance from the previous branch. On the surface of the hemisphere it gives off a number of branches running towards the caudal suprasylvian sulcus. Its terminal branch goes to the surface of the occipital lobe.

The inferior temporal branch (Figure 1-10) runs towards the end of the caudal suprasylvian sulcus. Having passed the posterior part of the sulcus, its terminal branches participate in supplying blood to a part of the occipital lobe.

As compared with the overall outline of the distribution of the cortical branches of the middle cerebral artery in the otter, one shall note that specific parts of these branches can, in some surfaces, be found inside particular sulci, sometimes undergoing further divisions, always heading towards the regions of the cortex described. Considering the pattern of departure of the cortical branches of the middle cerebral artery, in the otter specimens it was found that in all animals from the rostral cerebral artery there descended a single independent vessel: the middle cerebral artery.

In 10 (16.7%) of the cerebral hemispheres, the rostral branch was created from the common trunk for the anterior olfactoral artery and frontal branches. The main trunk emerged onto the surface of the cortex from the Sylvian fissure and created a common departure for parietal branches. Caudally from the main trunk of the middle cerebral artery there separated, with a common trunk, temporal branches with the posterior olfactoral artery. In another 13 (21.7%) cases from the main trunk of the middle cerebral artery rostrally there separated a branch for the anterior olfactoral artery, the orbital branch, and superior and inferior frontal branch.

The main trunk gave off parietal branches, the posterior olfactoral artery, the inferior temporal branch and, having ascended into the Sylvian fissure, it gave off the superior and middle temporal branch on the surface of the cortex.

In another 27 (45%) cases, from the main trunk of the middle cerebral artery rostrally there separated a common trunk for the anterior olfactoral artery and for the orbital branch. The common departure for the inferior and superior frontal branches, the main trunk gave rise to, caudally, the posterior olfactoral artery with the common departure with the inferior temporal branch. Having entered the Sylvian fissure, it gave off the common trunk for the anterior and posterior parietal arteries and the middle and superior temporal branch on the surface of the cerebral cortex.

In 8 (13.3%) cases, rostrally from the main trunk there descended independently the anterior olfactoral artery, then a common departure for the orbital branch and for the inferior frontal branch. Caudally from the main trunk there separated, with a common departure, the superior frontal branch, and the anterior and posterior parietal branches. The main trunk of the middle cerebral artery, having emerged onto the surface of the cortex, gave off the common trunk for temporal branches: inferior, middle and superior branches as well as the posterior olfactoral artery.

In the other 2 (3.3%) cases, rostrally from the main trunk there descended a common branch for the anterior olfactoral artery and the orbital branch, followed by the common trunk for the inferior and superior frontal branches. Caudally from the main trunk there separated the posterior olfactoral artery and temporal branches. Having penetrated the Sylvian fissure, the main trunk gave off a common branch for parietal branches on the surface of the cortex (Figure 2).

DISCUSSION

The middle cerebral artery supplies blood to the biggest area of the telencephalon and it is the best developed branch of all the vessels. In the otter the middle cerebral artery supplies the same cerebral areas as observed in the mammalian species investigated so far. Also, there are no discrepancies in the description of the terminal branches in respective animal species. The differences concern mostly the pattern of division of these vessels into respective branches.

Regarding the division pattern of the middle cerebral artery on the surface of the cerebral cortex, we found that it can be divided and described similarly as reported for the carnivore species studied by Wiland (1991). However, there were differences as compared with the description of the arteries provided by Walinczus (1973). In the pig this author identified an orbital branch, two frontal branches, two parietal branches and three temporal branches, as branches spreading on the surface of the cerebral cortex above the lateral rhinal sulcus. Chadzypanagiotis (1975) and Wiland (1991) did not report any branches as vessels on the border of the archicortex and the neocortex as well as vessels for the archicortex only. The arteries supplying the archicortex in the otter are small branches which reach the piriform lobe and olfactory tracts.

The branches found on the border of the archicortex and the neocortex cover the anterior and posterior olfactoral arteries. In 13.3% of the otter's studies here the anterior olfactoral artery was a vessel which departed from the main trunk of the middle cerebral artery independently. In the other specimens it separated with the common trunk with the orbital branch or with a common departure with the orbital branch, the inferior and superior frontal branches, whereas the posterior olfactoral artery in 16.6% of cases separated from the main trunk. In other hemispheres it was a branch of the common trunk for temporal branches or it departed directly from the inferior temporal branch.

The other cortical branches of the middle cerebral artery can be divided into groups of parietal, temporal and frontal branches. Similarly to various carnivores, in the otter there occur eight main vessels supplying blood to the same areas of the cerebral hemispheres. Specific cortical branches can depart from the main trunk of the artery with a common departure; Chadzypanagiotis (1975) or Wiland (1991) described such cases as the anterior, superior and posterior middle cerebral arteries.

In the otter the anterior middle cerebral artery was described as a common trunk for frontal branches (38.4% cases), while the superior middle cerebral artery – as the common trunk for parietal branches (20% cases). In 33.3% of cases the posterior middle cerebral artery was found to be the common trunk for temporal branches. In the otter the superior middle cerebral artery was least frequently observed, whereas the anterior middle cerebral artery predominated.

A comparison of the present results with those reported by Wiland (1991) demonstrates that also in carnivores the superior middle cerebral artery is least frequent. Similarly as in the other species investigated, parietal branches in the otter are least developed. On the surface of the telencephalon the best developed ones are the frontal branches of the middle cerebral artery. The reports on the middle cerebral artery provided by Jablonski et al. (2005) and Skoczylas et al. (2006) in the grivet and yellow baboon, respectively, show that it is usually a single vessel separating from the rostral cerebral artery. Having passed the lateral rhinal sulcus, it gets divided along its course into specific branches; its main trunk heads towards the brain vault, which, in the present study, was observed in 100% cases.

The present data demonstrate that the pattern of middle cerebral artery division in the otter shows the same branches or groups as in the other mammalian species investigated so far, which can be attributed to genetic limitations. As reported by Wiland (1980), the brain blood supply in individuals of a given species depends considerably on the genetic information accumulated over the phylogenetic development, not only within a given species but also the entire group.

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