

## FORMATION OF CEREBRAL ARTERIAL CIRCLE (CIRCULUS ARTERIOSUS CEREBRI) IN THE FETUS OF ZAVOT-BRED CATTLE

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Geliş Tarihi:

**Summary:** Nourishment of the brain in mammals is provided by the circle of Willis (circulus arteriosus cerebri), a unique structure made up by several arteries. This study aimed at revealing the construction of this circle in the fetuses of the Zavot cattle raised in Kars and its province. Fifteen fetuses, regardless of their sex, at the age of 2-7 months were used in the study. Methodically, colored-latex was injected by way of both the right and left common carotid arteries, followed by dissection. Arteries joining the formation of the circle of Willis were observed as follow; the right and left internal carotid arteries (a. carotis interna dextra et sinistra) laterally, the termination of the basilar artery (a. basilaris) caudally, and the internal ethmoidal (a. ethmoidalis interna) and internal ophthalmic (a. ophthalmica interna) arteries cranially. Patterns and origins of these arteries were also determined in the present study. The right and left vertebral arteries united directly to form the basilar artery without dividing into the cranial and caudal rami.

**Key words:** Cerebral arterial circle, fetus, vascularization

### Zavot Irkı Sığır Fetuslarında Willis Poligonu'nun Formasyonu

**Özet:** Memelilerde beyin, pek çok damarın ortaklaşa oluşturduğu bir çember, Willis Poligonu, tarafından beslenmektedir. Bu çalışma Kars ve çevresinde yetiştirilen Zavot ırkı sığır fetuslarında çemberin oluşumunu ortaya çıkarmayı amaçlamaktadır. Çalışmada cinsiyet farkı gözetmeksizin 2-7 aylık 15 adet fetus kullanıldı. Materyallere a. carotis dextra ve sinistra yolu ile renklendirilmiş latex verildi ve takiben diseksiyon uygulaması ile çember gözlemlendi. Çemberin yanlardan a. carotis interna dextra et sinistra, arkadan a. basilaris, ve ön taraftan a. ethmoidalis interna ve a. ophthalmica interna tarafından oluşturulduğu belirlendi. Çalışmada bu damarların başlangıçları ve seyirleri de incelendi. Sağ ve sol a. vertebralis'in dallanma göstermeden a. basilaris'i direkt olarak oluşturduğu gözlemlendi.

**Anahtar Sözcükler:** Circulus arteriosus cerebri, fetus, vaskularizasyon

### INTRODUCTION

Nourishment of the brain in mammals is supplied by the cerebral arterial circle (circle of Willis), a unique structure formed by the terminal branches of the internal carotid and basilar arteries. Structural formation of the circle has been amply reported in these animals<sup>1-5</sup>. Moreover, its structure possesses different formation in adult artiodactyls due to the unusual pattern of the internal carotid arteries which are usually occluded after birth<sup>6,7</sup>. Due to this occlusion, the internal carotid arteries originate from the epidural rete (rete mirabile epidurale) in the adult artiodactyls<sup>8,9</sup>.

The gross structure of the rete and its connection with the circle of Willis in artiodactyls have frequently been documented<sup>10-13</sup>. On the other hand, those of the different breeds, in this case the Zavot cattle mostly raised in the northeast Turkey, are not commonly seen in the literature. Investigation of these anatomical structures of the fetus of Zavot cattle to the literature

is thought to be valuable and interesting. This study, thus, aimed at revealing the construction of this circle in the fetuses of the Zavot cattle raised in Kars and its province, which is very famous for its high milk and meat production at very cold climates.

### MATERIALS and METHODS

Fetuses were collected from a local slaughterhouse in Kars, a city located in Eastern Anatolia, and their ages were determined by using the method of Richardson et al. 1990<sup>14</sup>, in which they predicted the age of the fetus by examining the crown-hump length as well as at the bodyweight. The results of the study, carried out according to this method, showed that the age of the fetuses ranged from 2 to 7 months.

Thoracic cavities of 15 fetuses were firstly opened and the arteries, particularly those supplying the head were washed with 0.9 % saline via the left ventricle of the hearth. The colored-latex, ZPK-582-G produced by Educational & Scientific Products Ltd.,

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Rustington, West Sussex, was injected through both the right and left common carotid arteries and the fetuses were put in 10% formaldehyde fixative solution for 48 hours. Finally, dissection was performed and the vessels forming the circle documented. *Nomina Anatomica Veterinaria, 1992*<sup>15</sup> was employed for the anatomical nomenclature.

## RESULTS

The circle of Willis (Fig. 1) in Zavot fetuses was characterized as resembling the number "8" in shape. Arteries forming the circle were the following; the left (Fig. 1/1) and right (Fig. 1/2) internal carotid arteries laterally, the termination of the basilar artery (Fig. 1/3) caudally, and the internal ethmoidal (Fig. 1/4) and internal ophthalmic arteries cranially.

The right and left internal carotid arteries originating directly from the right and left common arteries, respectively, joined the epidural rete, and emerged through the base of the brain, near the optic chiasm and hypophysis. They, in turn, were terminated by dividing into the rostral cerebral (Fig. 1/5) and caudal communicating (Fig. 1/6) arteries. Thereby, the rostral choroidal artery (Fig. 1/7) originated.

The basilar artery was formed by unification of both vertebral arteries (Fig. 1/8). The caudal unification of them descended through the vertebral canal as the ventral spinal artery (Fig. 1/9). The basilar artery sent the following branches bilaterally, respectively; the caudal cerebellar artery (Fig. 1/10), the labyrinthine artery, and the pontine branches, during its rostral course on the ventral surface of the brain. It, then, joined the right and left caudal communicating arteries at the level of the cerebellar tentorium.

Cranially, the internal ophthalmic and internal ethmoidal arteries contributed bilaterally to the construction of the circle. The right and left rostral cerebral arteries run rostromedially dorsal to the optic nerve, received first the internal ophthalmic, then internal ethmoidal arteries. They, at the same time, gave off the middle cerebral arteries (Fig. 1/11) which went laterally to the Sylvian fissure. The middle cerebral arteries distributed several smaller branches in front of the piriform area before entering the fissure, and advanced dorsally in the fissure, extending over the lateral surface of the brain. The

rostral cerebral arteries, finally, communicated at the cranial pole of the circle, via a very short and thin rostral communicating artery, which sent the rostral meningeal arteries (Fig. 1/12), supplying the cranial part of the brain. The rostral cerebral arteries gave also several smaller subbranches directly to the brain.

The right and left caudal communicating arteries from each internal carotid arteries coursed caudomedially, joined the terminal branches of the basilar artery in front of the pons, constructing the lateral and caudal parts of the circle. While doing that, they gave bilaterally the caudal cerebral (Fig. 1/13) and rostral cerebellar (Fig. 1/14) arteries, and

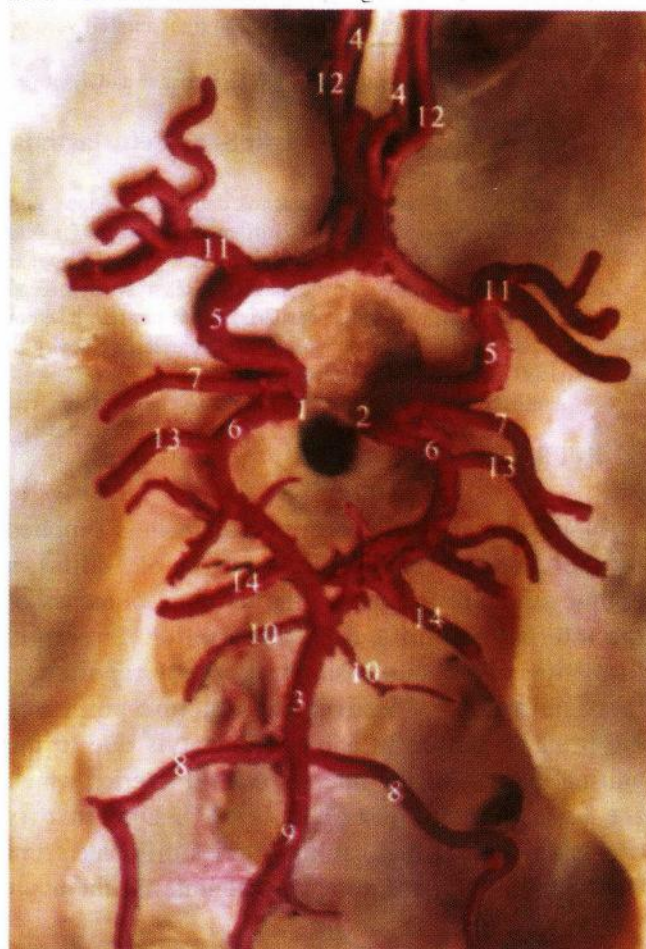


Figure 1: Formation of the circle of Willis in the fetus of Zavot-bred cattle, X5.

1-Left internal carotid artery, 2-right internal carotid artery, 3-basilar artery, 4-internal ethmoidal artery, 5-rostral cerebral artery, 6-caudal communicating artery, 7-rostral choroidal artery, 8-vertebral artery, 9-ventral spinal artery, 10-caudal cerebellar artery, 11-middle cerebral artery, 12- rostral meningeal arteries, 13-caudal cerebral artery, 14-rostral cerebellar artery.

Resim 1: Zavot ırkı siğir fetüslerinde Willis Poligonu'nun formasyonu, X5.  
1-A. carotis interna sinistra, 2-A. carotis interna dextra, 3-a. basilaris, 4-a. ethmoidalis interna, 5-a. cerebrolis rostralis, 6-a. communicans caudalis, 7-a. choroidalis rostralis, 8-a. vertebralis, 9-a. spinalis ventralis, 10-a. cerebellaris caudalis, 11-a. cerebrolis media, 12-a. meningeae rostralis, 13-a. cerebrolis caudalis, 14-a. cerebellaris rostralis.

numerous smaller branches.

The caudal cerebral arteries on either side left the caudal communicating arteries at the level of the caudolateral aspect of the pituitary gland. They divided into two main branches while coursing dorsocaudally to the lateral aspect of the thalamus. These branches sometimes originated directly from the caudal communicating arteries. They consequently were subdivided into several smaller branches, supplying the caudal aspect of the brain.

The rostral cerebellar arteries arose from the caudal communicating arteries at the level of the caudal third of the circle. They, then, supplied the caudal midbrain and the rostral part of the cerebellum by giving off two main subbranches. These, in some cases, originated directly from the caudal communicating arteries.

## DISCUSSION

Formation of the circle of Willis supplying the brain in the fetuses of the Zavot cattle raised in Kars and its province has been the focus of this research. This breed is very famous for its high milk and meat production at very cold climates in eastern Anatolia. This basic value led us search on the gross morphology of this breed whether there is (are) significant structural difference(s) as compared to the current bovine literature.

Studies<sup>2-4,11</sup> have documented the general pattern of the internal carotid artery which is the main component of the circle. Although its extradural pattern is completely different in the fetal stage than in the postnatal period in bovine<sup>10-13</sup>, this artery is the main component of the circle as displayed in the literature<sup>2,11,12,16</sup>. Similar to the literature, this study showed the internal carotid artery of the Zavot fetuses to originate from the common carotid artery at the level of the first cervical vertebra, thus joining the epidural rete, then terminating in the circle.

The results documented here on the structure of the circle in the Zavot fetuses were superficially in resemblance with the data in the literature<sup>7</sup>. There were, though, significant differences that are thought to be related to the breed and species on the morphology of the circle. The formation of the basilar

artery by the vertebral arteries were different than that indicated as the common bovine pattern in the literature<sup>2-4,11</sup>. These studies have documented that the right and left vertebral arteries normally divide in the vertebral canal into the cranial and caudal ramus. The cranial rami unite, in the midline, forming the basilar artery cranially while the caudal ones joins and forms the ventral spinal artery caudally. This pattern was not seen in this study. The vertebral arteries in this study, indeed, united directly and form the basilar artery without dividing into cranial and caudal rami.

Although the right and left rostral cerebral arteries in this study showed superficially similar pattern as compared to the literature<sup>2-4,11</sup> it is very interesting to indicate that the cranial communicating artery connecting the right and left rostral cerebral arteries was very sort and thin. The cranial communicating artery in the literature, however, have been documented to be a thick and eminent one communicating the right and left rostral cerebral arteries.

Pattern of the caudal communicating arteries were similar to the literature<sup>2-4,11,17</sup> while their branch distribution were dissimilar in origin. Both the caudal cerebral and rostral cerebellar arteries divided into two main branches. These branches sometimes interestingly originated directly from the caudal communicating arteries, consequently being subdivided into several smaller branches

In conclusion, there were significant differences especially on the pattern of the arteries forming the circle in Zavot fetuses, as compared to the normal pattern in bovine in the literature. Formation of the basilar artery by the vertebral arteries were unique. The cranial communicating artery, thus, connecting the right and left rostral cerebral arteries was very sort and thin. Finally, branch distribution of the caudal communicating artery was dissimilar in origin with what has been said in bovine literature so far.

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