EURASIAN
JOURNAL OF VETERINARY SCIENCES
www.eurasianjvetsci.org - www.ejvs.selcuk.edu.tr

RESEARCH ARTICLE

Circulus arteriosus formation in cat brain

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Özet

Gomes MS, Dias GP, Silva MPSS, Santos CM, Abidu-Figueiredo M. Kedi beyininde circulus arteiosus'un yapısı. **Eurasian J Vet Sci, 2012, 28, 4, 204-208**

Amaç: Bu çalışmanın amacı, kedide her iki cinsiyete ait circulus arteriosus'u oluşturan yapıların tanımlanmasıdır.

Gereç ve Yöntem: Çalışma, burun-sakrum uzunluğu sırası ile 47.9 cm ve 46.6 cm olan 25 erkek ve 25 dişi yetişkin kedi kadavrası üzerinde gerçekleştirildi. Kediler sağ lateral tarafa yatırıldı, torakal ensizyon ile 6. ve 7. torakal kostalar uzaklaştırılarak aortanın torakal bölümü kanüle edildi. Kediler %10 formol solüsyonu ile tespit edilip boyalı latex solüsyonu enjekte edildikten sonra craniumlar açıldı ve beyin diseke edilerek circulus arteriosus'un yapısı tanımlandı.

Bulgular: Beyinin tabanında yer alan arterler, arteria carotis ve vertebral-basillar sistemden köken alan ve beyinin arteriel vaskularizasyonundan sorumlu olan arterlerdi. Circulus arteriosus'un rostral bölümünün, arteria communicans rostralis'in varlığı durumunda hayvanların % 46'sında bu arter tarafından kapatıldığı, arka bölümünün ise hayvanların tamamında kapalı olduğu tespit edildi.

Öneri: Encephalon'un basal yüzünün kan damarlarının muhtemel varyasyonlarını, dağılımını ve yerleşimini inceleyen çalışmalar, evcil memeli hayvanlarda klinik ve cerrahi yaklaşımların gelişimine katkı sağlayacaktır.

Abstract

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Aim: The aim of this study was to describe the formation of the circulus arteriosus of the brain in cats of both sexes.

Materials and Methods: Anatomical dissections were performed on 50 cadavers of adult cats, 25 males and 25 females, with a medium rostrum-sacral length of 47.9 cm and 46.6 cm respectively. Cats were positioned in right lateral recumbency and a thoracic incision was performed to remove the 6th and 7th ribs to cannulate the thoracic portion of the aorta. After fixed with a 10% formaldehyde solution and injected with latex solution stained with pigment, the cats went through craniotomy and dissection of the brain to identify the formation of the circulus arteriosus.

Results: The arteries of the base of the brain were dependent of the carotid and vertebral-basilar systems, which were responsible for the brain arterial circuit formation. The brain circuit was rostrally closed by the presence of the rostral communicating artery in 46% of the animals and caudally closed in 100%.

Conclusions: Studies that clarify the organization, distribution and possible variations of the blood vessels of the encephalon base, certainly will contribute for the advance in the clinical-surgical boarding in domestic animals.

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Received: 15.08.2012, Accepted: 17.09.2012
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Anahtar kelimeler: Damarlaşma, merkezi sinir sistemi, kedi

Keywords: Irrigation, central nervous system, feline

► Introduction

The disorders that affect the central nervous system (CNS) represent an important parcel of the diseases observed in the clinical-surgical practice of domestic animals, and are responsible for a great amount of deaths and sequels. Several are the pathological processes that affect the cerebral blood vessels such as embolisms, hemorrhages and thrombosis. As result of these events we find a deficiency in irrigation and the consequent injury (Meneses 2006). Therefore, studies that clarify the organization, distribution and possible variations of the blood vessels of the encephalon base, certainly will contribute for the advance in the clinical-surgical approach in domestic animals.

The base of the brain is frequently the headquarters of several nosological processes that require surgical or invasive neuroradiologic intervention, thus, researches become significant in this area, influencing the indices of mortality and morbidity. The surgical boarding of this region not only requires a perfect anatomical knowledge of the habitual morphology, but also of the variations of the diverse structures that are found in there. Based on that fact, many authors have dedicated great attention to the morphology of the cerebral vascularization and, in particular, the morphology of the circulus arteriosus in diverse surgical contexts, normally, in tumors of the brain base. In recent years, great advances in diagnostic imaging techniques were observed. Those techniques are used to investigate the structures of the central nervous system, improving this way, the prognostic and treatment of different pathologies (Quinones-Hinojosa et al 2006, Szeifert et al 2007). As result to that, the diagnose to many diseases of the nervous system became more frequent and precise, allowing many advances in the biomedical research, providing safe and minimally invasive treatments (Kano et al 2009, Simon and Schramm 2009).

In 1664, Thomas Willis was the first one to anatomically describe in human beings, the so-called cerebral arterial circle (Mc Donald and Poter 1951, Young and Young 1998), also known in the specific literature as polygon of Willis and circle of Willis. The polygon of Willis denomination was presented by Cambier et al (1999), the circle of Willis term by De Vriese (1905), the cerebral arterial circle denomination by Schaller (1999), while Alcantara and Prada (1996a) adopted in their works the term arterial circuit of the encephalon. The circulus arteriosus is composed by the basilar and carotid arteries, in different percentages of participation.

The aim of this study was to describe the encephalic circulus arteriosus formation in cats of both genders and thereby provide knowledge the studies of neuroimage and neurosurgery.

► Materials and Methods

All the used cadavers were yielded to the Animal Anatomy Area (Biology Department) of the UFRRJ–Federal Rural University of Rio de Janeiro, congealed and stored in freezers since they were received. Fifty adult cats (without defined breed) were used: 25 males and 25 females. Initially the cadavers were defrosted in flowing water and identified by placing numbered plastic tags attached with a string to the calcaneal tendon of the animals. The rostrum-sacral length of each animal was measured with a precision measuring tape, from the extremity of the snout to the insertion of the tail. The cadavers were positioned in right lateral recumbency and then an incision between the 6th and 10th intercostal spaces was performed to access the thoracic portion of the aorta. The artery was cannulated with a urethral catheter (number eight or ten, according to the artery diameter) fixed with a string to prevent extravasation and to keep the intravascular pressure. The fixation was made by injecting 10 % formaldehyde solution (variable volume in function of the cadaver weight), through the catheter in cranial direction. Immediately after the fixation of the cadavers, a colored solution of Petrolátex S65 was injected, to fill all the arterial system. After that, the cadavers were immersed in low density polyethylene boxes with 500 liters of capacity, containing 10 % formaldehyde solution, used to finish the fixation process and the latex polymerization. Seven days after the latex injection, the cadavers were washed in flowing water and dissected. This experiment is part of the project titled - Vascular anatomy in the cat: study destined to the surgical and experimental practices, and to the diagnostic imaging. Submitted and approved by the ethics and research committee of the UFRRJ, under the process number 23083.005334/2009-49.

The mean and the standard deviation of the animal length were calculated. These measures were compared between the genders using the unpaired t-test, considering $p<0.05$ as significant. In order to verify if the distribution of observed frequencies for the 50 examined animals was consistent with literature, the chi-square test was applied, considering the 5% significance level to test if the nullity hypothesis is true, regarding the shape of the rostral cerebral artery and the presence of the rostral communicant artery. All the data was processed in the Graphpad Prism® software.

► Results

The rostrum-sacral length was 50.66±3.83 on males and 46.88±4.22 ($p<0.0019$) on females. The general arrangement of the arteries of the encephalon base in both genders, depended of the carotid and vertebrobasilar systems, and was established from blood vessels, which through its divisions, varied in number and disposition, expressing different structural and functional meanings. The disposal and the arrange-

ment presented by the arteries of the encephalon base of the cats characterized the circulus arteriosus of the encephalon, which was observed surrounding the mamillary body, interpeduncular fossa, tuber cinereum, hypophysis and the optic chiasm. The circulus arteriosus extends itself from the pons to the rostral portion of the optic chiasm (Figure 1).

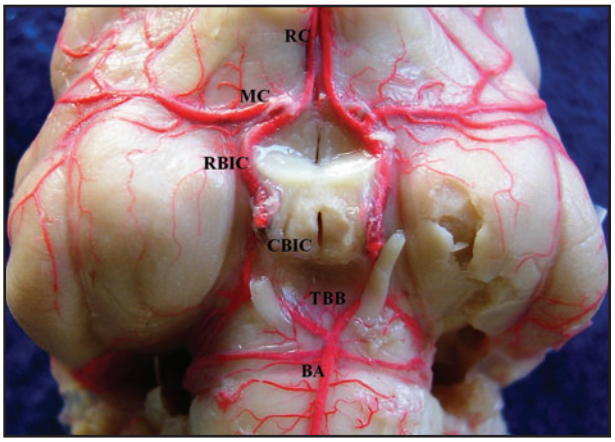

Figure 1. Photomacrography showing a general view of the circulus arteriosus cerebri in cats (RC: Rostral cerebral artery, MC: Middle cerebral artery, RBIC: Rostral branch of the internal carotid artery, CBIC: Caudal branch of the internal carotid artery, TBB: Terminal branch of the basilar artery, BA: Basilar artery).

► Discussion

The circulus arteriosus of the brain in domestic and wild animals can be used to create models that simulate man, with the purpose to conduct different experiments. This way, the detailed comparative morphologic study of these blood vessels becomes essential and relevant. Studies of the circulus arteriosus of the encephalon base in different species demonstrated many variations. Nazer and Campos (2011) in ostrich (Struthio camelus) observed that it appeared rostrally open in 100% and caudally opened in 80% of cases. Almeida and Campos (2011), in the broad-snouted caiman (Caiman latirostris), verified that this was exclusively dependent of the carotid system, and presented itself rostrally and caudally closed in all the studied specimens, similar to the results obtained by Azambuja (2007) studying nutria (Myocastor coypus), although the circuit in these animals was supplied exclusively by the vertebrobasilar system. In the present inquiry, the circuit was dependent of the carotid and vertebrobasilar systems, similar to the observed by Lima et al (2006) in cats (Felis catus domesticus), presenting itself rostrally closed in 46% of the animals due to the presence of the rostral communicant artery, and caudally closed in 100%.

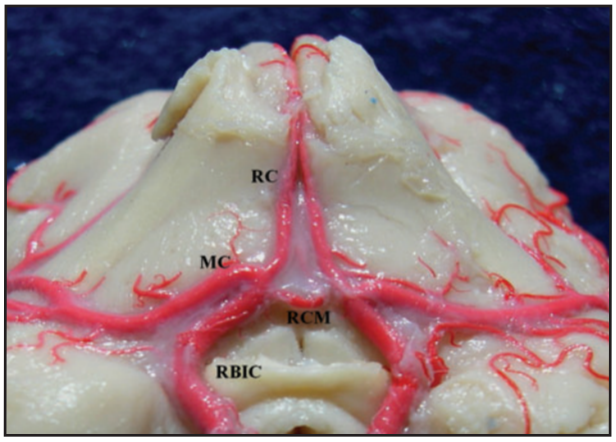

Figure 2. Photomacrography showing the rostral portion of the circulus arteriosus cerebri in cats (RC: Rostral cerebral artery, MC: Middle cerebral artery, RCM: Rostral communicant artery, RBIC: Rostral branch of the internal carotid artery).

The caudal branches of the internal carotid artery of the encephalon, in both antimeres, originated from the homonymous arteries, were caudally directed, and finished after the caudal cerebral arteries emergence, promoting their anastomosis in the ventral surface of the cerebral peduncles with the respective terminals branches of the basilar artery, that presented themselves in the form of two half circles in the right and left hemisphere.

The rostral branches of the internal carotid artery in its progression originated the right and left middle cerebral artery. The rostral branches of the internal carotid artery were linked by the rostral communicant artery in 16 males (64%) and in 17 females (68%) (Figure 2). The circulus arteriosus of the brain was rostrally open in nine and caudally closed in all the dissected males. In females, it was presented rostrally open in eight animals and caudally closed in all the dissected females. In both genders, in none of the samples, the circulus arteriosus was similar to a geometric figure.

The right and left middle cerebral arteries heading toward the rostral portion of encephalon originated the right and left rostral cerebral arteries. In eight males (32%), right and left rostral cerebral arteries crossed themselves, and in 17 males (68%) they were in rectilinear form. In 15 females (60%) the right and left rostral cerebral arteries crossed themselves and in 10 females (40%) they had rectilinear form, configuring in both cases the arterious circle of the cat encephalon.

The swine (Sus scrofa domesticus) circulus arteriosus is rostrally closed because of the presence of the rostral communicant artery in 100% of the cases and caudally by the presence of the right and left terminal branches of the basilar artery (Ferreira and Prada 2005), similar to the observed in the wild boar (Sus scrofa scrofa) (Oliveira and Campos 2005), and differently from the observed in the present inquiry.

Lima et al (2006) observed in cats that the circuit was rostrally closed by the presence of the rostral communicant artery in 60% of the cases and caudally closed by the presence of the caudal branches of the carotid

arteries and terminal branches of the basilar artery in all the samples, similar to the observed in the present research.

Ocal et al (1999) concluded that the circulus arteriosus in camel (Camelus dromedarius) had its sanguineous supply derived from the carotid artery, in each antimer, by the basilar artery and the caudal communicant artery which was originated from the rostral epidural rete mirabile. In cats of this study, although the similarities of the circuit formation (carotid and basilar artery), the formation of the caudal communicant artery was not observed, unlike what was seen in camels.

Araujo and Campos (2005) related that the sanguineous irrigation of the chinchilla (Chinchilla lanigera) encephalon was formed by the vertebrobasilar system and in smaller proportions by the left internal carotid artery or by the vertebrobasilar system, with contribution of the left internal carotid artery. In capybara (Hydrochoerus hydrochaeris), Reckziegel et al (2001) found that sanguineous irrigation of the encephalon depends only of the vertebrobasilar system, partially corroborating with the results obtained by this study in cats, where besides the involvement of the vertebrobasilar system, the involvement of the carotid system was also observed.

In the circulus arteriosus of the red squirrel (Sciurus vulgaris), the internal carotid artery did not contribute for its sanguine supplement, which is done by the basilar artery (Aydin 2008). Similar morphologic arrangement was observed by Aydin et al (2009) in the ground squirrel (Spermophilus citellus) and by Aydin et al (2005) in the porcupine (Hystrix cristata). Our results showed that not only the basilar artery has participation, but also the carotid artery.

According to Lima et al (2006), the circulus arteriosus extends itself from the pons to the optic chiasm rostrally, being represented by the right and left carotid artery through their rostral and caudal branches, and also by the terminal branches in both antimeres, besides the basilar artery, corroborating with the results of the present inquiry.

In relation to the form of the circulus arteriosus, Lima et al (2006) report that the arrangement of the rostral branches remembers an ellipsoid figure, arranged transversely in relation to the encephalon base, differently of the results observed for the same species in this research, where the circulus arteriosus did not present any similar configuration to a geometric form. However, in relation to the rostral cerebral artery, the rectilinear form predominated in the males and the crossed shape in the females.

In mammals, the variations of the brain base arteries can be explained by the influence of genetic and environmental factors (Wiland 1974). According to this author, the variation does not mean to exceed some limits defined by the phylogenetic development of the systematic group of mammals.

► Conclusion

The results of this inquiry showed that the circulus arteriosus of the cat depends on the carotid and vertebrobasilar systems. There was a predominance of the rectilinear form of the rostral cerebral artery in males and the crossed shape in females, although the presence of the rostral communicant artery was independent of the gender.

► Acknowledgements

This study was part of a research supported by the Council for Improvement of Graduated Students (CAPES).

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