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Anatomical study of arterial blood supply of the brain in local breed rabbit

A.A. Hasso

Department of Anatomy, College of Veterinary Medicine, University of Mosul, Mosul, Iraq

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Correspondence:
A.A. Hasso
adnanhassoali@gmail.com

Abstract

Current work aims to investigate the brain blood supply of the local rabbit, where 14 rabbits of both sexes were used with weights ranging from 3-3.5 kg. This study revealed that the rabbit's brain is supplied by the vertebral and internal carotid artery (ICA). The union of the vertebral arteries creates the basilar artery that runs on the ventral surface of the pons and medulla oblongata, forming at its end the posterior communicating arteries (PCA), as well as at the path of the basilar artery from which the following arteries are formed, which are the anterior cerebellar arteries, pons arteries, 1st posterior cerebellar artery, 2nd posterior cerebellar artery, and the medullary arteries. The ICA enters the cranium through the foramen lacerum, forming the anterior carotid network, from which an artery exits anteriorly, called the intracranial part of the ICA, and caudally exits the (PCA). The following arteries are created from the intracranial part of the ICA, which is the accessory anterior communicating artery that connects with the posterior communicating artery and the posterior cerebral artery (PCEA) forming the closed circle of Willis, the middle cerebral artery is also created anteriorly and laterally to distributed on the two cerebral hemispheres of the brain, as well as the anterior cerebral artery which directed forward to gives the marginal artery which represents the first terminal branch of the anterior cerebral artery, and at the marginal artery going toward the olfactory tract and then to the olfactory bulb from which the internal ethmoidal artery is created. The anterior communicating artery originates from the anterior cerebral artery and it is a small artery communicating the left and right anterior cerebral arteries with each other, and the posterior cerebral artery originates from the PCA, as well as the anterior cerebellar arteries arising from the PCA and accessory posterior communicating artery (APCA) and the anterior part of basilar artery, to supply the hemispheres of the cerebellum and the cerebellar vermis.

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Introduction

It is no secret that the brain has great importance in regulating vital processes in the body and the importance of the brain is focused on sustaining life by being appropriate to its surroundings (1). The distribution of arteries in the brain of animals, including mammals, took great interest by those responsible for the studies on the arteries of the brain in various animals, including a description of the blood supply of the giraffe by Frackowiak *et al.* (2), Felidae by Frackowiak *et al.* (3), European beaver by Frackowiak *et al.* (4), fallow deer by Godynicki (5), deer by Godynicki (6), dog, sheep and other mammals by Kapoor *et al.* (7), Gerbil by Kuchinka *et al.* (8), Egyptian mouse by Szczurokowski *et al.* (9), squirrel by Ayidin (10) and bovine species by Zduin *et al.* (11). The chinchilla's blood supply was described by (12-14). There are very few studies on brain blood supply in rabbits (15-17). The lack of studies specialized in the brain blood supply of rabbit especially in the local rabbit, in particular, prompted us to

carry out this study, through which we will highlight the blood supply of the nervous system inside the cranium.

Materials and method

Fourteen adult healthy rabbits regardless to sex with weight ranging between 3-3.5 kg were taken from the local markets of the city of Mosul. The rabbits were anesthetized by inhalation of chloroform, then an incision was made in the neck area to check the common carotid artery (CCA), to open it and make the animal bleeding, then, 5000 IU of heparin was mixed with normal saline and injected to remove the leftover blood and thrombus present in blood vessels, After that 10% formalin solution was injected into the blood vessels for fixation and then the CCA was closed by artery forceps and placed in 10% formalin solution for 72 hours (17).

After that the samples were removed from the formalin solution and washed well with running tap water, then the blood vessels in the other side of the neck were locked to ensure the pass of latex to the head only without spreading to the whole body. After that the samples were injected with the latex substance added to the carmine material, so the carmine works to add color to the latex. The injection was done by the same method of injection of formalin in the body and through the CCA, and then locking the artery with artery forceps and samples were left for 48 hours to solidify the latex. Then the skin and skull bones were removed and the brain, meninges, and part of the spinal cord were harvested (17).

Results

By following the injected blood vessels, the brain of rabbit was supplied with blood by the vertebral and ICA, the vertebral arteries on both sides connected to form the basal artery that runs along the ventral surface of the pons and medulla oblongata (Figure 1).

On its way, the basal artery send several divisions to end at anterior part near the pons and forming the PCA (Figure 2 and 3), where they originate from the anterior part of the basal artery, as well as, the anterior cerebellar arteries originate from the lateral surface of the basal artery at both sides, it forms an acute angle with the basal artery (Figure 2,3), also pons arteries are created, which are small arteries that originated from the lateral surface of the basal artery on both sides, the number ranges from 2-3 arteries on each side (Figure 2 and 3).

Also, the study showed that the 1st posterior cerebellar artery originate from the lateral surface of the basal artery on both sides, and it anastomoses with the 2nd posterior cerebellar artery that creates a large artery called the posterior cerebellar artery to creates one large posterior cerebellar artery, which branched into several branches that goes to the cerebellum and cerebellar vermis as in (Figure 1-4). We also note the medullary arteries, which are small arteries that originate from the lateral surface of basal artery, and both sides are distributed to ventral surface of medulla oblongata (Figure 1 and 3).

Figure 1: Shows the blood supply and arterial distribution of ventral side of the brain of the local rabbit. a- Vertebral artery b- Basal artery c- Posterior communicating arteries d- medullary arteries e- Posterior cerebellar artery (first and second) f- Middle cerebral artery g- Anterior cerebral artery h- marginal artery i- internal ethmoidal artery.

The ICA is one of the terminal branches of the CCA, It enters the cranium through the foramen lacerum, which branched into several branches and forming the anterior carotid network which is a group of small arteries located at the base of the brain on either side of the pituitary gland in which an anterior artery appears as the intracranial part of the ICA and the posterior artery is the exit from the anterior carotid network and along the ventral side of brain stem which called posterior communicating artery (PCA) (Figure 2-5), also from the intracranial portion of ICA exit artery called accessory anterior communicating artery extends backward to connect with PCA and posterior cerebral artery (Figure 2) forming the closed Willis circle.

The middle cerebral artery (MCA) is created from the intracranial part of the ICA and represents a continuation of the ICA (Figure 1), where it goes forward and laterally to

be distributed on lateral surfaces of two cerebral hemispheres. Also creates the anterior cerebral artery (ACA) which is one of the terminal part of ICA going forward direction (Figure 1 and 3), Also, we observe the marginal artery, which represents the first terminal part of the ACA that extends forward in front of the medial border of the two cerebral hemispheres (Figure 1 and 3), furthermore, the internal ethmoidal artery is created from the lateral side of the marginal artery which extends after giving internal ethmoidal artery anteriorly and laterally to the olfactory tract and then the olfactory bulb (Figure 1 and 3).

The study revealed that the anterior communicating artery arises from the anterior cerebral artery, which is a small artery communicating the right and left ACA (Figure 3), whereas the PCA arises from the anterior carotid network (Figure 2 and 3) and connect it to the basal artery.

This study appeared that the PCA goes backward on the ventral side of brain stem, where the left and right arteries join to create the anterior part of basal artery (Figure 2).

The PCEA arises from the lateral surface of PCA near its middle (Figure 2 and 3), directed back and laterally on ventral side of brain stem, we also note the anterior cerebellar arteries, which are a group of 4-5 arteries in each side that arise from the PCA and the APCA and the anterior part of basal artery (Figure 3). It is directed laterally on the ventral side of brain stem, then dorsally and inverted, to distribute in the frontal part of the cerebellar and cerebellar vermis.

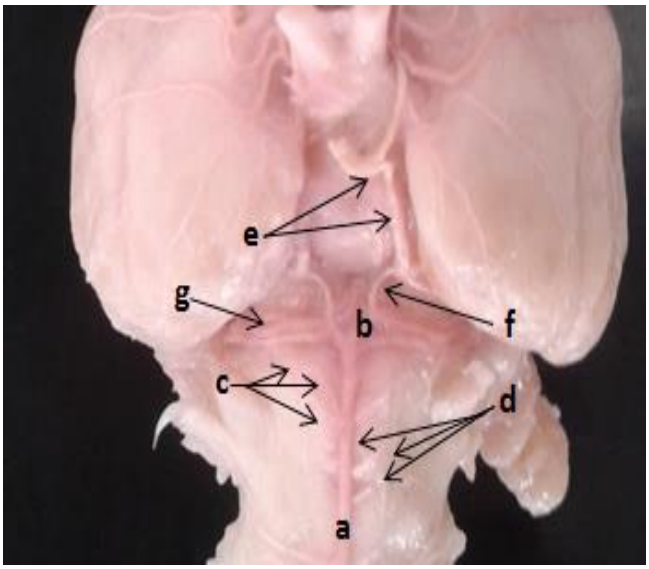

Figure 2: Shows the arterial distribution of the base and pons of the brain and the spinal cord of the local rabbit brain a- Basal artery b- Posterior communicating arteries c- anterior cerebellar arteries d- pontine arteries e- intracranial part of the internal carotid artery f- accessory anterior communicating artery g- posterior cerebral artery.

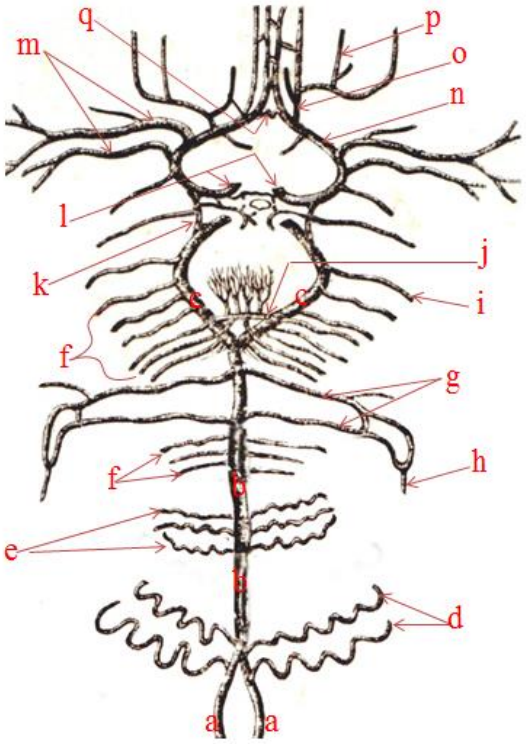

Figure 3: Diagram showing the arterial distribution of the brain in the local rabbit. a- Vertebral artery b- Basal artery c- Posterior communicating arteries d- medullary arteries. e- Pontine arteries f- anterior cerebellar arteries. g- Posterior cerebellar artery (first and second). h- Large cerebellar artery i- posterior cerebral artery. j- Accessory posterior communicating artery. k- Accessory anterior communicating artery. I- intracranial part of the internal carotid artery. m- Middle cerebral artery n- Anterior cerebral artery. o- Marginal artery p- internal ethmoidal artery. q- Anterior communicating artery.

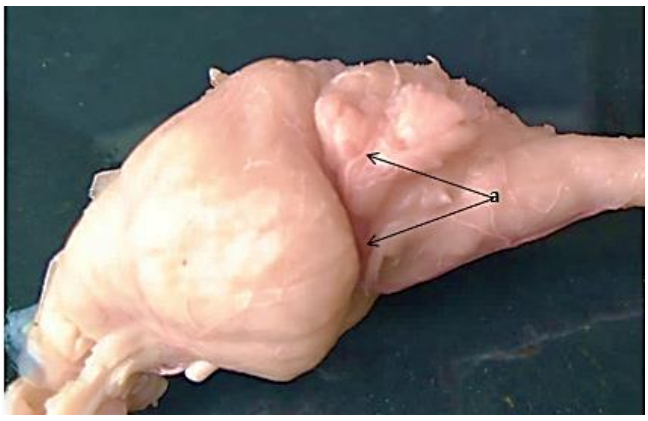

Figure 4: Shows the lateral surface of the rabbit's brain. (a) large posterior cerebellar artery.

Figure 5: Shows the lateral surface of Rabbit's head after lifting the skin and part of the facial muscles. (a) common carotid artery (b) internal carotid artery.

Discussion

The blood supply of the brain in rabbits, generally, is similar to most other mammals where the vertebral artery and ICA are considered the chief source of blood supply to the brain. The fused left and right vertebral arteries from the basal artery that supplies the blood to the ventral aspect of brain, similar results were reported by Frackowiak *et al.* (4) In the European beaver who mentioned that the vertebral arteries on either side fuse to form the basilar artery, which supplies blood to the circulus arteriosus.

Our results approve the findings of Brudnicki *et al.* (18) in wild rabbits and (17) in New Zealand rabbits who mentioned that the chief source which supply blood to the rabbit brain is the vertebral arteries, which anastomosis to form the basilar artery in addition to the internal carotid arteries. Whereas Aydin *et al.* (19) mentioned that the ground squirrel's brain is supplied by the left and right vertebral arteries only without referring to the internal carotid artery. This difference in the blood supply of the brain depends on species variations. On its way, the basal artery provides several divisions to end at anterior part near the pons and forming the posterior communicating arteries, where they originate from the anterior part of basal artery. ACA originate from the lateral aspect of the basal artery at both sides, they form an acute angle with the basal artery, also pons arteries which are 2-3 small arteries which originate from the lateral surface of basal artery on both sides. Similar results were recorded by Ayidin *et al.* (19) in their study on the ground squirrel, who mentioned that the cerebellar and pontine arteries emerged from the basilar artery just before its end.

Also, this study noticed that the 1st PCA originate from the lateral surface of basal artery on both sides, and it anastomoses with the 2nd posterior cerebellar artery that creates one large posterior cerebellar artery, which gives rise several branches that goes to the cerebellum and cerebellar vermis. Our results confirm the results of Fernanda and Rui (17) who described the basilar artery in New Zealand rabbit where he mentioned that it creates lateral branches at different angles to the right and left, which are two posterior communicating arteries that supply the cerebellum and the cerebellar vermis. The anastomosis of the communicating arteries behind the posterior segment of the ICA creates the posterior cerebellar artery, which continues dorsally to reach the choroid plexus of the fourth ventricle and the caudal lobes of cerebellum. In addition to the above-mentioned branches of the basilar artery, it gives rise to small arteries from its lateral surface called the medullary arteries that distributed on the ventral side of medulla oblongata.

On the other hand, Oscar *et al.* (17,20) who mentioned that the ICA in New Zealand rabbit is one of the terminal branches of the common carotid artery where enters the cranium through the foramen lacerum, then gives branches that directed forwards and backwards, thus will contributing to form the Willis circle. Actually, the above description of internal carotid artery was similar to our findings in local breed rabbit, additionally, the middle cerebral artery is created from the intracranial part of the internal carotid artery and represents a continuation of the ICA, where goes forward and laterally to be distributed on the lateral side of two cerebral hemispheres. Also, the ACA which created from intracranial ICA going forward direction to give rise the marginal artery, that extends forward in front of the medial border of the two cerebral hemispheres, furthermore, the internal ethmoidal artery is created from the lateral side of marginal artery which extends anteriorly and laterally to the olfactory tract and then to olfactory bulb. These results were described only by *Oscar et al.* (20) in his study on New Zealand rabbit's brain, where he mentioned that the MCA originates from the ICA then directed laterally to feed the two hemispheres of the brain.

The anterior communicating artery, which is a small artery communicating the right and left ACA arises from the anterior cerebral artery whereas the posterior communicating artery originate from the anterior carotid network and connects it to basal artery. This result was similar to that mentioned by Fernanda and Rui (17) in New Zealand rabbit but disagree with Aydin *et al.* (19) in his study on the ground squirrel, who mentioned that the two ACA join together and form the closed arterial circuit and the absence of the anterior communicating artery in this animal, while he mentioned the presence of the posterior communicating artery that unites with the basilar artery at the ventral surface of the medulla oblongata. This difference may be explained by the absence of the anterior communicating artery in the ground squirrel.

The posterior cerebral artery originates from the middle of the lateral surface of the PCA artery, directed back and laterally on the ventral side of brain stem while the anterior cerebellar arteries, which are a group of 4-5 arteries on each side that arise from the PCA and the APCA and from anterior part of basal artery. It is directed laterally on the ventral side of brain stem, then dorsally and inverted, to distribute in the frontal part of the cerebellar and cerebellar vermis. This result comes in agreement with Aydin *et al.* (19) who mentioned that the basilar artery exits from both sides of the cerebellar and pontine arteries before reaching the two posterior communicating arteries at its end, which enter in the formation of the cerebral arterial circuit (Willis circle).

Conclusion

This study concluded that the intracranial part of the ICA and basilar arteries are the main arteries that supply the brain of rabbits with blood.

Acknowledgments

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Conflict of interest

The authors declare that there is no conflict of interest regarding publishing or funding of this article.

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دراسة تشريحية للمدد الشرياني لدماغ الأرنب المحلي

عدنان علي حسو

فرع التشريح، كلية الطب البيطري، جامعة الموصل، الموصل، العراق

الخلاصة

هدفت هذه الدراسة إلى التحري عن المدد الدموي الشرياني لدماغ الأرنب المحلي، حيث استخدم ١٤ أرنبا من كلا الجنسين وبأوزان تتراوح بين ٣-٣,٥ كغم. أظهرت الدراسة أن دماغ الأرنب يغذى عن طريق الشريان الفقاري والشريان السباتي الداخلي، وان اتحاد الشريانيين الفقاريين ينتج الشريان القاعدي الذي يسير على السطح البطني لقنطرة الدماغ والنخاع المستطيل، مكونا في نهايته الشريانين الموصلين الخلفيين، كذلك عند مسير الشريان القاعدي ينشأ منه الشرايين الأتية وهي الشرايين المخيخية الامامية والشرايين القنطرية والشريان المخيخي الخلفي (الأول) والشريان المخيخي الخلفي (الثاني) والشرايين النخاعية. أما الشريان السباتي الداخلي الذي يدخل القحف من خلال الثقب المتهتك مكونا الشبكة السباتية الأمامية والتي يخرج منها أماميا شريانا يطلق عليه الجزء داخل القحف من الشريان السباتي الداخلي، أما خلفيا فيخرج منها الشريان الموصل الخلفي. تنشأ الشرايين التالية من الجزء داخل القحف للشريان السباتي الداخلي وهي الشـــريان

الموصل الأمامي الإضافي الذي يرتبط مع الشريان الموصل الخلفي والشريان المخي الخلفي مكون بذلك دائرة ويلز المغلقة، كما ينشأ أيضا الشريان المخي الأوسط متجها أماميا ووحشيا ليتوزع على نصفي كرة المخ، كذلك الشريان المخي الأمامي متجها إلى الأمام ليعطي الشريان الهامشي الذي يمثل الفرع الانتهائي الأول للشريان المخي الأمامي، وعند مسير الشريان الهامشي إلى المسلك الشمي والبصلة الشمية ينشأ منه الشريان المصفاوي الداخلي. ينشأ الشريان الموصل الأمامي من الشريان المخي الأمامي وهو شريان صغير يربط الشريانان المخيان الأماميان الأيمن والأيسر مع بعض، وينشأ الشريان المخي الخلفي من الشريان الموصل الخلفي، كذلك نلاحظ الشرايين المخيخية الأمامية تنشأ من الشريان الموصل الخلفي والشريان الموصل الخلفي الإضافي ومن الجزء الأمامي للشريان القاعدي لتغذي نصفي كرة المخيخ والدودة المخيخية.