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Sources of Arterial Vascularization of the Polar Owl's Kidneys

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Abstract

The sources of vascularization of the kidneys of five polar owl carcasses were studied by filling the vessels with self-hardening plastic Belokril through the femoral artery. High-grade oil paints were added to the monomer to give the vessels the desired color. After the injection, the carcasses were placed in a high concentration caustic soda solution for three days. The resulting corrosion impression was washed under warm water and dried. It was identified that in the lumbar trunk, the main vessel was the descending aorta, from which extra- and intraorganic arteries departed for vascularizing the kidneys. Extraorganic arteries included external and internal iliac, sciatic and middle sacral arteries. Intraorganic arteries included cranial, middle, and caudal renal arteries. Inside the parenchyma of each lobe of the kidney, intraorganic arteries branched in the main type of caudomedial, dorsomedial and lateromedial directions and were subdivided into segmental, interlobular and perilobular arteries and intralobular capillaries. An asymmetry in the branching of the renal arteries was observed. During histological examination, we noted that the renal arteries were lined with endothelium on the inner side and the intima contained endotheliocytes with oval nuclei. Under the endothelial layer were loose collagen fibers running along the middle shell. There was no loose connective tissue between the inner and middle shells, so the subendothelial layer was very weak and there was no internal elastic membrane. The muscle membrane was well developed, with collagen and elastic fibers located between the muscle fibers. The outer shell was represented by loose connective tissue with the presence of arterial and venous vessels. The collagen fibers had a slightly convoluted course.

Keywords: birds, polar owl, arteries, kidneys, parenchyma, capillaries, endotheliocytes, intima.

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1. Introduction

Currently, due to the anthropogenic factors, it is important to breed wild birds in captivity to preserve the variety of birds of prey by protecting their natural habitat and breeding in artificial conditions (wildlife reserves, national parks, specially protected natural areas) [1, 2].

Zoos and nurseries play an important role in the preservation of rare species. Ideal conditions are created for the reproduction of rare birds and preservation of the gene pool by creating viable groups in open-air cages [3, 4]

During the evolution, the birds learned to flight, acquired greater mobility, increased metabolism and a urinary apparatus with a special structure, which is one of the most important departments in the metabolic processes of the body [5]. The urinary apparatus is of paramount physiological importance in the formation and excretion of urine, which is closely connected with the arterial and venous systems [6, 7]. In this regard, the study of the sources of vascularization is of particular importance for the diagnosis and prognosis of diseases of the urinary apparatus. Information about the sources of renal vascularization is the main factor in the treatment of wild bird species.

Studies of the arterial system of the kidneys is of particular importance. They are associated with their high physiological activity, filtration and excretion of decay products. The arterial bed has a certain structural plan, characterized by the sequence of arterial vessels distributed in accordance with the hemodynamic direction of blood flow through the paired organs.

In the Russian and foreign literature, despite the extensive information on the morphology of the arteries of the pelvic girdle in domestic and wild birds, information on features of the main vessels in the posterior part of the body is scarce [8–10]. There is no information on the topography of large arterial vessels of the pelvic girdle organs in birds of prey. Despite the advances in modern anatomy of birds, there is no data on intraorgan branching of arteries in the organs of the posterior trunk and urinary system [7, 10, 12].

The research objects were five carcasses (male and female). The birds were clinically healthy, had normal development, and good physique conditions

The research purpose is to study the extraorganic and intraorganic branching of the kidney arteries in the polar owl.

2. Methods and Equipment

The main methodological principle for obtaining scientific information was a comprehensive study of the sources of vascularization of the kidneys in the polar owl. To accomplish this task, a complex of morphological studies of the arteries involved in the vascularization of the kidneys by pouring the vessels through the femoral artery of the self-hardening plastic of the acrylic series “Belokril” was used. High-grade oil paints were added to the monomer to give the vessels the desired color. After the injection of the vessels, the carcasses of the birds were placed in a high concentration caustic soda solution for three days. The resulting corrosion impression was washed under a warm shower and dried

3. Results

Due to a high level of metabolism and a significant functional load on the urinary system, a large amount of arterial blood flows through the kidneys performing the main physiological function of filtration and elimination of substances unnecessary to the body and forming urine.

The main vessel in the lumbar region is the descending aorta - aorta descendens - being a continuation of the aortic arch with a diameter of 4.22 ± 0.01 mm (in male polar owls) / 4.91 ± 0.01 mm (in female polar owls). The external iliac, paired cranial renal arteries depart from the descending aorta. The external iliac artery departs from the descending aorta at the level of the first-third vertebra. External iliac right and left arteries run in the craniomedial direction along the ventral surface of the kidneys, crossing each kidney along its entire length in the connective tissue groove. The diameter of the external iliac artery is 2.20 ± 0.02 mm (male) / 2.26 ± 0.04 mm (female), ($p < 0.05$).

After leaving the external iliac artery, the descending aorta becomes the middle sacral artery. It has a diameter of 2.40 ± 0.03 mm (male) / 2.62 ± 0.04 mm (female), ($p < 0.05$).

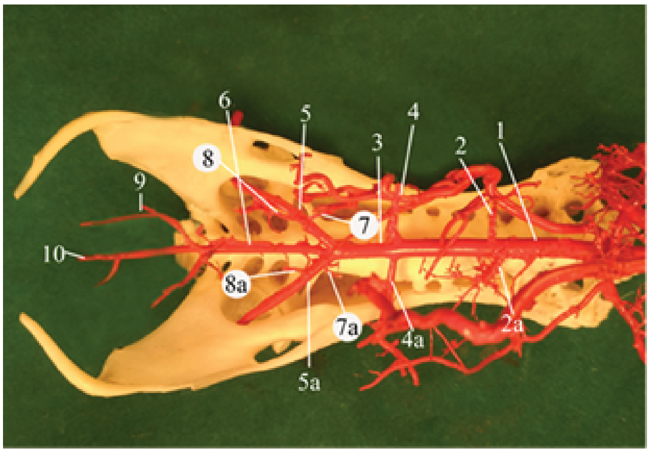

Figure 1: Sources of renal vascularization in polar owls (photo from a corrosive preparation): 1 - descending aorta; 2 - cranial renal right aorta; 2a - cranial renal left aorta; 3 - middle sacral aorta; 4 - external iliac right aorta; 4a - left external iliac aorta; 5 - sciatic right aorta; 5a - ischial left aorta; 6 - middle sacral aorta; 7 - middle renal right aorta; 7a - middle renal left aorta; 8 - caudal renal right aorta; 8a - caudal renal left aorta; 9 - internal iliac aorta; 10 - caudal medial aorta.

The sciatic right and left arteries depart from the middle sacral artery in the caudolateral direction. They form deep vascular impressions on the ventral surface of the kidneys.

The sciatic artery passes between the middle and caudal lobes of each kidney, located in the connective tissue vascular groove. The middle and caudal renal arteries depart from the sciatic arteries into the corresponding lobes of the kidneys. The sciatic artery has a diameter of 0.85 ± 0.04 mm (male) / 1.08 ± 0.02 mm (female), ($p < 0.05$).

The middle sacral artery departs from the sciatic artery and passes in the caudal direction towards the cloaca. It is called the middle tail artery and has a diameter of 0.96 ± 0.01 mm (male) / 1.10 ± 0.01 mm (female), ($p < 0.05$).

The main vessels involved in the renal vascularization are the cranial, middle, and caudal renal arteries.

The cranial renal right and left arteries - aa. renales craniales dextra et sinistra - depart from the lateral surface of the descending aorta at the level of the last thoracic and first lumbar vertebrae. They serve as sources of vascularization of the right and left cranial lobes of the kidneys. All segmental arteries enter each lobe of the kidney, dividing inside it according to the main type, and then form an umbrella.

The cranial renal right artery is divided into three main branches that enter the cranial lobe of the kidney and are divided according to the main type in the lateral, caudolateral and caudal directions. The diameter of the cranial renal artery is 0.69 ± 0.02 mm (male) / 0.75 ± 0.01 mm (female), ($p < 0.05$).

There are several types of branching of the cranial renal arteries were observed.

The middle renal right and left arteries - aa. renalis medialis dextra et sinistra - depart from the sciatic artery into the middle lobes of each kidney. Within each lobe, they run cranioventrally towards the cranial lobe, along the entire length of the kidney. The diameter of the middle renal artery is 0.62 ± 0.02 mm (male) / 0.69 ± 0.02 mm (female), ($p < 0.05$).

The right and left caudal renal arteries depart from both sciatic arteries into the renal parenchyma.

The caudal renal arteries - aa. renalis caudalis - are directed caudoventrally and vascularize the medial surface of the parenchyma of the caudal lobes. In the polar owl, one or two segmental arteries branch off into the caudal lobe, which are divided into six-eight interlobular arteries, branching in the caudomedial, dorsomedial and lateromedial directions. 9-11 arteries depart from each one and branch out. 12-15 capillaries located

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parallel to each other depart from them. The diameter of the caudal renal artery is 1.01 ± 0.01 mm (male) / 1.09 ± 0.01 mm (female), ($p < 0.05$).

The histological examination identified that the renal arteries are lined with endothelium from the inside, the intima contains endothelial cells with oval nuclei. Loose collagen fibers running along the middle shell are located under the endothelial layer. There is no loose connective tissue between the inner and middle membranes, therefore the subendothelial layer is weakly expressed and there is no inner elastic membrane. The muscular layer is well developed, has 25-27 layers of muscle fibers, between which there are 26-28 layers of collagen and elastic fibers. The outer shell is represented by loose connective tissue with arterial and venous vessels. Collagen fibers have a slightly curled course.

The internal iliac right and left arteries branch off from the middle tail artery. The caudal mesenteric artery - a. mesenterica caudalis – departs from the dorsal surface of the middle tail artery cranioventrally and brings blood to the muscular stomach, spleen and pancreas, jejunum, cecum and rectum.

4. Discussion

From the descending aorta, the external iliac arteries depart, which are associated with translational movements and with strong development of the pelvic limb muscles, which is consistent with [12–14]. Analyzing the morphofunctional parameters of the relationship between the angles of departure of the external iliac arteries and the structure of the pelvic bones, we found that in the polar owl, the external iliac arteries depart at an angle of 78° - 83°, which is associated with relatively short pelvic bones in relation to the length of the trunk and well-developed limbs.

We do not agree with the opinion [6, 7], who noted that the cranial, middle and caudal renal arteries branch off from the descending aorta for the corresponding kidney lobes, entering the center of each lobe.

As a result of morphometric analysis, we note that the ratio of the diameter of the cranial renal artery to the descending aorta in the polar owl is 16.3% (male), 15.2% (female), the middle renal artery is 14.6% (male), 14.0% (female), the caudal renal artery is 23.9% (male), 22.1% (female).

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5. Conclusion

In the lumbar trunk of the bird species, the main vessel is the descending aorta, from which extra- and intraorganic arteries depart for vascularization of the kidneys. Extraorganic arteries include external and internal iliac, sciatic, and middle sacral ones. Intraorgan arteries include cranial, middle, and caudal renal arteries, which disintegrate into segmental and interlobular, perlobular arteries and intralobular capillaries.

Taking into account the segmental structure of kidneys, which are subdivided into cranial, middle, and caudal lobes, the sources of vascularization are cranial, middle and caudal renal arteries, which are located at the border of each lobe and participate in their blood supply, which is consistent with the data in [5, 6, 10]. In this case, each renal artery is divided dichotomously and vascularize the anterior and posterior parts of the corresponding lobe of the kidney.

A morphometric analysis showed that the ratio of the diameter of the cranial renal artery to the descending aorta is 16.3% (male) / 15.2% (female), to the middle renal artery - 14.6% (male) / 14,0% (female), to the caudal renal artery - 23.9% (male) / 22.1% (female). The branching asymmetry is typical of the renal arteries.

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Conflict of Interest

The authors have no conflicts of interest.

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