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Abdominal Arteries Diameter Assessment by using Doppler Ultrasonography in Pregnant Local Female Rabbits

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Abstract:

Background: The abdominal and pelvic arteries play an important role in regulating blood flow to vital organs, especially during pregnancy due to the numerous physiological changes that occur to ensure adequate blood flow to the fetus and its supporting tissues. Latex injection is also an effective tool for revealing the anatomical distribution of arteries. Ten pregnant female domestic rabbits were used. Color Doppler ultrasound of the celiac arteries was performed from the dorsal position. The rabbits were then anesthetized and given a latex injection via the left ventricle.

Aims: This study aims to evaluate the abdominal arteries in pregnant female rabbits using color Doppler, providing reference data on their diameters. It also seeks to study the major anatomical locations of the abdominal arteries using intravascular latex injection.

Results: Color Doppler ultrasound results showed that the mean hepatic artery diameter was (0.196 ±0.005) cm and the mean renal artery diameter was (0.292 ±0.009) cm. Anatomically, The results of latex injection showed that the injected arteries retained their anatomical flexibility, which helped clearly show the anatomical path of the arteries and facilitated the process of identifying their locations and anatomical relationships with the adjacent tissues. The results indicated that the aorta was the main artery supplying the abdomen, which in turn branches into the celiac artery, which gives off two major branches: the splenic artery and the common trunk, the mesenteric artery, and the two renal arteries, where the right renal artery was located higher in origin and shorter in length than the left renal artery.

Conclusions: Color Doppler ultrasound also provides a clear and accurate image of the artery's diameter, but it cannot image all the arteries that appear when a rabbit carcass is injected with latex for several reasons, including the interference of fat and other tissues with the arteries.

Keyword: Vascular ultrasound, latex, pregnant rabbits

Introduction

In the past years, rabbit have been used as an animal model for studying hyperlipidemia atherosclerosis and restenosis after vascular intervention (Ebert *et al.,* 2025). Vascular structure has a close relationship with vascular function including curvature and branch geometry; therefore, good health can be seen as a compromise between a curvy structure and high liminality (Du *et al., 2023*). Pregnancy is a period of great metabolic activity in the female body, which undergoes hemodynamic changes to meet the metabolic requirements of the conceptus (Sanchez *et al.*, 2021). Hormonal and hemodynamic alterations specifically cause structural and physiological changes in arteries (Ahmed *et al.*, 2024). There is an increase in plasma volume that occurs during pregnancy, along with changes in cardiac output and blood pressure (Eke, 2022). These physiological changes lead to adaptations to the vascular structure that enable the system to adjust to the new metabolic demands (Augustin & Koh, 2024). Many studies during pregnancy have examined changes in the smaller arteries and arterioles, such as the uterine and placental blood vessels (Fournier *et al., 2011*).

However, few have examined changes in the large elastic arteries, such as the aorta of pregnant mammals (Vargas *et al., 2021*). It is important and hard to do anatomical studies of the vascular system in the abdominal cavity for ultrasonography, surgery on people and animals, and research that needs to understand how vascular hemodynamics work (Al-Saffar & Almayahi, 2019). Ultrasonography is an accurate, reliable, non-invasive imaging technology with no side effects (Lazim & Al-Watar, 2025). Recently, studies have developed simple and cost-effective techniques to facilitate practical and in-depth experiments on vascular anatomy. Therefore, it can be used in Doppler mode to non-invasive assessment the shape and geometry of arterial walls of abdominal (Maslak *et al., 2021*), to detect and treat vascular disorders increased vascular resistance in the mother during pregnancy will have an impact on the baby and mother during pregnancy (Parikh *et al.*, 2021).

Ultrasound equipment has developed rapidly and turned out to have various advantages one of which is the examination of blood vessels (Wang *et al.,* 2021). In vascular studies, rabbits serve as

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excellent animal models because of their size and relatively low cost (Al mayahi & M., 2024). The rabbit has the advantage of having a cardiovascular system comparable to that of humans in terms of hemodynamic parameters and arteriovenous pressure gradients (Beslika *et al.,* 2024). Our aim in this study was to study the main anatomical locations of the abdominal arteries by injecting latex into the arteries and to provide reference data for the diameter of the abdominal arteries using color Doppler in healthy pregnant rabbits.

Materials and Methods:

Ultrasound scanning

Before to examination, animals were anesthetized by intramuscular (IM) injection of ketamine (0.5 mg/kg) (Noor & Ahmed, 2024). The abdominal hair was then carefully shaved and complete ultrasound examinations were performed on the rabbits using the same ventral approach with the animal lying supine and then examined dorsally, ventrally and laterally. All images were taken using a Z50Vet ultrasound machine in color Doppler mode with frequency of (5-7) MHz and (depth of 4.5-6.5) mm, which was maintained and checked regularly. Multiple scanning planes were used to evaluate the major blood vessels in the abdomen. Also image magnification was used continuously and applied in all scans to provide the most accurate measurements (Sulaiman *et al., 2025*).

Anatomical examination

During the necropsy, pregnant rabbits were anesthetized by intramuscular injection with xylazine (0.30 mg/kg) and ketamine (0.15 mg/kg) IM (Noor & Ahmed, 2024). The group of five specimens (rabbits) was injected with red-stained latex (carmine dye) via the left ventricle of the heart. After dissection and injection, the abdominal cavity was opened using anatomical instruments to manually remove the stomach and small and large intestines located under the roof of the abdomen to obtain a better image of the blood vessel. Study the active branching of the abdominal aorta and observe the distribution of arteries in the abdominal organs. These specimens were then preserved in 10% Neutral buffered formalin for 24 h and then withdrawn from the fixation medium and carefully dissected (Rojo *et al.,* 2023) (Naser & Khaleel, 2020).

Ethical approval

The Scientific Ethical Committee of the College of Veterinary Medicine, University of Diyala, Iraq, approved this study (Approval no: Vet Medicine (VM 181 July 2024 A, R and R). Five pregnant female rabbits were selected at the age of (2-3) years and weight (1.5-2.0) kg. All rabbits were housed in a sterile animal room air conditioning, maintained at a temperature of 23°C ± 2°C and humidity of 65% ± 5% (Rusul, 2024).

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Results:

Ultrasonography Results

The present study used ultrasound to identify the arteries based on their anatomical location, color Doppler activation, and pulse. We observed that the blood arteries feeding the abdomen include the (portal vein (PV) and hepatic artery (HA) which supply the liver and renal vein (RV) and renal artery (RA), which supply the kidneys. However, the aorta and some branches were difficult to detect because they were obscured by the abdominal organs such as the stomach, intestines and liver, which lie above them. Ultrasound imaging was performed in the upper abdomen in the dorsal position, and the (gallbladder, HA, and PV) were identified after activating the color Doppler mode. The diameter of HA was also identified where HA was found to be (0.196 ±0.005) cm with a frequency of (6.0 MHz) and a depth of (4.6) (Fig. 1). When imaging was performed on both sides of body, in the ventral, dorsal, and lateral positions in the kidney region, the (RA) and (RV) were identified after activating the color Doppler mode, in addition to that, the arterial diameter (0.292 ±0.009) cm of the kidney was measured at a frequency (6.0 MHz) and depth (3.7) mm (Fig. 3). However, with color Doppler ultrasound, the artery was found to be red, while the vein was found to be blue (Fig. 2, 4)

Figure (1): Photograph of color Doppler ultrasound image shows the Doppler modes of the liver in pregnant female rabbit diameter measurements of the hepatic artery (HA).

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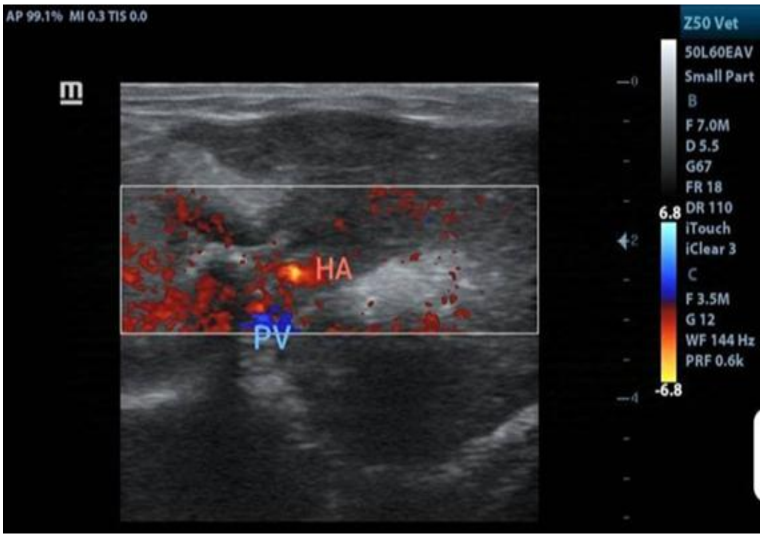

Figure (2): Photograph of color doppler ultrasound shows the area of the hepatic artery and portal vein in a pregnant rabbit. (HA: hepatic artery, PV: portal vein).

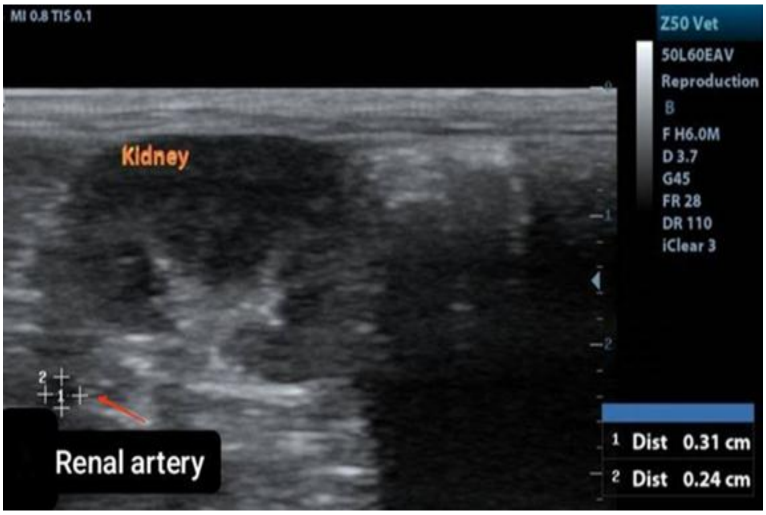

Figure (3): Photograph of color Doppler ultrasound image shows the doppler modes of the kidney in pregnant female rabbit diameter measurements of the renal artery.

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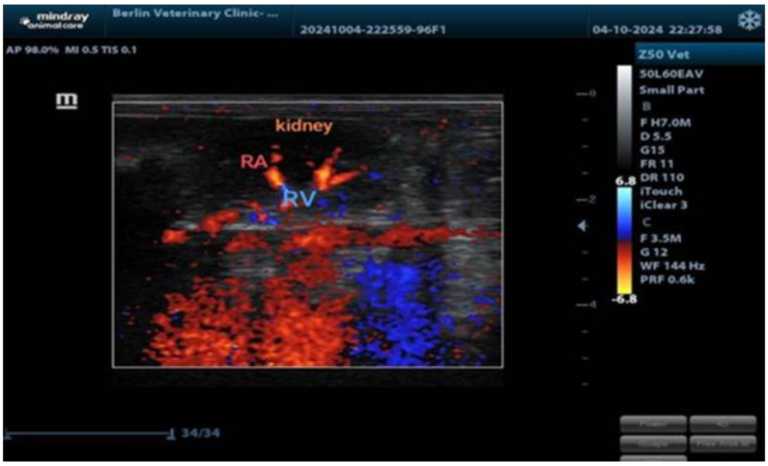

Figure (4): Photograph of color doppler ultrasound shows the area of the renal arteries and veins in a pregnant rabbit. (RA: Renal artery, RV: Renal vein).

Morphological results

The results showed that the main artery that supplies the intestine is the abdominal aorta, which extends from the thoracic aorta and eventually branches into the two iliac arteries in the pelvic region (Fig.5). The first branch of the abdominal aorta is the celiac artery (Fig.5), which in turn branches into two main arteries: the splenic artery, which gives off 4 branches (Fig.6) and the common trunk, which supplied the left gastric artery and the hepatic artery, which is called the visceral artery because it supplies the viscera. The second branch was the superior mesenteric artery, which supplies the largest part of the intestine (Fig.5). The celiac artery met the superior mesenteric artery at the duodenal artery. The third branch that extended from the abdominal aorta was the right and left renal arteries (Fig.5). The right and left suprarenal arteries arise at the beginning of each renal artery. During pregnancy, the uterus increases in size, and thus the uterine arteries are formed between the abdominal and pelvic regions. The uterine artery branches off from the internal iliac artery and reaches the abdomen in the third week of pregnancy (Fig.7).

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Figure (5): An Anatomical view shows the distribution of arterial blood supply injected with the latex in the abdominal vessels of a pregnant female rabbit: 1- Abdominal aorta. 2- Celiac artery. 4- Right-Renal Artery. 5- Left-renal artery. 6- Left-suprarenal artery. 7- Right iliac artery. 8- Left iliac artery. 9- Splenic artery. 10- Left gastric artery. 11- Hepatic artery.

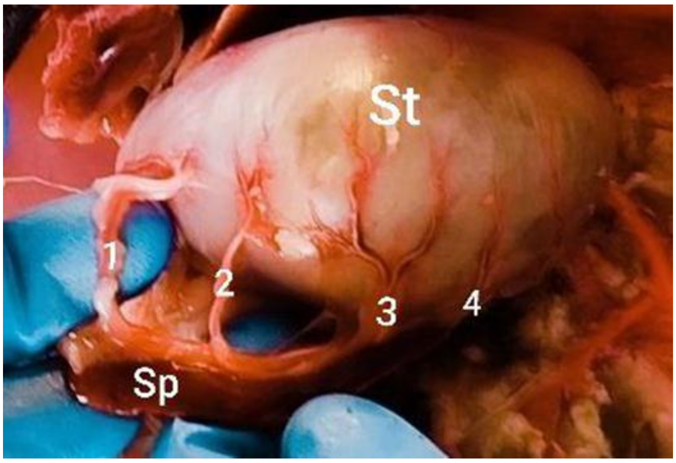

Figure (6): Anatomical dissection of the stomach image shows the branches of the splenic arteries, which give off four branches of the splenic arteries (1,2,3 and 4). (ST:stomach, Sp: spleen).

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Figure (7): Anatomical dissection of the uterine image shows the arteries that supply the uterus. 1- Abdominal aorta. 2- Enternal iliac artery. 3- Uterine artery. (Em: Uterus with Embryo).

Discussion

Ultrasound imaging techniques are vital tools in assessing vascular kinetic functions and providing valuable insights into hemodynamics. The present findings confirm the value of ultrasound, particularly color Doppler imaging, in identifying abdominal vasculature in rabbits. The hepatic artery (HA), portal vein (PV), renal vein (RV), and renal artery (RA) were successfully visualized based on their anatomical location, pulsation, and Doppler characteristics. The use of 6.0 MHz frequency and optimal imaging depth enhanced the resolution and vascular contrast, consistent with previous studies in small animal models (Zotti et al., 2010). The color Doppler findings, showing arteries in red and veins in blue, align with the standard Doppler convention where flow direction relative to the probe determines the color coding. This is a crucial aspect in differentiating arterial from venous flow in clinical and experimental settings (Thrall, 2017).The identification of vessels in different scanning planes (dorsal, ventral, lateral) confirms the reproducibility and reliability of sonographic imaging in rabbits, which enhances its utility in longitudinal vascular studies, especially in pregnancy or pathological conditions.

In the current, the color Doppler ultrasound findings in this study demonstrate the high effectiveness of this imaging modality in identifying hepatic vascular structures in rabbits, particularly during pregnancy. The hepatic artery (HA) and portal vein (PV) were clearly distinguished based on the direction of blood flow. In the current, When comparing the Doppler ultrasound of the current study with the previous study (Sulaiman *et al., 2025*) it was found the reduced diameter measured for the hepatic artery may indicate a relative decrease in hepatic perfusion or a mild increase in vascular resistance during pregnancy. Such alterations may result from physiological adaptations in maternal circulation, where blood flow is redistributed to prioritize uteroplacental supply, potentially at the expense of hepatic circulation (Kremkau, 2015). The clear

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visualization of these vessels also reflects proper scanning technique, including the dorsal abdominal position and appropriate transducer settings for small animals.These findings align with previous research on pregnancy-related hemodynamic changes in laboratory animals, which suggest that pregnancy induces functional and structural vascular adaptations in major visceral organs (Zotti *et al*., 2010; Thrall, 2017).

Physiological studies indicate that pregnancy induces significant alterations in renal hemodynamics. During the early and mid-stages of gestation, there is typically an increase in renal blood flow, resulting from reduced vascular resistance and elevated metabolic demands of both the mother and the developing fetus (Sturgiss *et al*., 2001; Conrad, 2004). These changes often lead to a slight increase in the diameter of the renal artery, as the vessel walls dilate in response to enhanced perfusion and relatively decreased intrarenal pressure (Podymow & August, 2005). Vascular evaluation was performed using Doppler ultrasound after liver transplantation to determine the outcome of the operation (Sanyal *et al.,* 2014). Also, renal artery stenosis can be assessed using Doppler ultrasonography (Granata *et al.*, 2009).

The latex-injected via anatomical study improves the accuracy of the study by providing further understanding for the difference between the main blood vessels and their main branches. This is shown by the results of this study. Our current research is consistent with the work of other authors who have employed latex with a vascular supply to facilitate the examination of blood vessels in the abdominal and pelvic compartments of cats (Rojo *et al.*, 2023) and rodents (Casal *et al., 2017*) as well as the arterial supply of the brain in rabbits (Hasso, 2022) and the human brain (Pérez *et al., 2024*) in humans. By tracing the latex-injected celiac arteries, the celiac blood supply of rabbits is similar to that of most other animals and humans, with the celiac artery being the primary source of blood flow to the abdomen. Our most recent investigations have shown that the celiac artery branches into two main branches: the SA and the CT (Flešárová & Maženský, 2016). The common trunk secretes the CHA and LGA. Our study is in agreement with New Zealand rabbits (Özdemir *et al., 2013*) and cats (Rojo *et al.*, 2023). In chinchillas, the CA secretes four main branches: the LGA, HA, SA, and the celiac gastrocnemius (Özdemir *et al., 2013*). The present research has observed that the RA is the third branch of the aorta. These studies agree that the correct branch arises anteriorly of the left branch because it is removed by the stomach and viscera on the left side (Popesko *et al.*, 1990). This study disagrees that rabbits the RA almost originated at the same level (Mazensky & Flesarova 2017).

Conclusions:

We conclude that injecting latex into the arteries provides a clear and accurate picture of the arterial location. Color Doppler ultrasound provides a clear and accurate picture of the arterial diameter. Ultrasound examinations cannot visualize all the arteries that appear when a rabbit carcass is injected with latex for several reasons, including the interference of fat and other tissues with the arteries.

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Recommendations:

It is recommended to compare the results of color ultrasound with other imaging techniques, such as magnetic resonance imaging (MRI) or X-rays, to determine the advantages of each technique.

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Conflict of Interest:

The authors assert the absence of any conflicts of interest.

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Authors Contributions:

This research was conducted entirely by the authors, who were responsible for study design, data collection, data analysis, and writing of the final manuscript.

References:

Ahmed, B., Rahman, A. A., Lee, S., & Malhotra, R. (2024). The implications of aging on vascular health. International journal of molecular sciences, 25(20), 11188.https://doi.org/10.3390/ijms252011188

Al mayahi, M. S. (2024). Histological and Histochemical study of Lungs in Domestic Rabbits (Oryctolagus Cuniculus). Diyala Journal for Veterinary Sciences. 2(4); 1–14.DOI: https://doi.org/10.71375/djvs.2024.02401

Al-Saffar, F. J., & Almayahi, M. S. (2019). Structural study of uterine tubes of the rabbit (Oryctolagus cuniculus) at different postnatal periods. Iraqi Journal of Veterinary Sciences, 33(2).https://doi.org/10.33899/ijvs.2019.162911

Augustin, H. G., & Koh, G. Y. (2024). A systems view of the vascular endothelium in health and disease. Cell, 187(18), 4833-4858.https://doi.org/10.1016/j.cell.2024.07.012

Beslika, E., Leite-Moreira, A., De Windt, L. J., & da Costa Martins, P. A. (2024). Large animal models of pressure overload-induced cardiac left ventricular hypertrophy to study remodelling of the human heart with aortic stenosis. Cardiovascular Research, 120(5), 461-475.https://doi.org/10.1093/cvr/cvae045

Casal, D., Pais, D., Iria, I., Videira, P. A., Mota-Silva, E., Alves, S., ... & Goyri-O'Neill, J. (2017). Blood supply to the integument of the abdomen of the rat: A surgical perspective. Plastic and

DJVS Diyala Journal for Veterinary Sciences مجلة ديالى للعلوم البيطرية

P-ISSN: 2410-8863
E-ISSN:2958-6178
https://djvs.uodiyala.edu.iq
Pages: 55-67

Diyala Journal for Veterinary Sciences
Vol. 3 No.2 June (2025)
https://doi.org/10.71375/djvs.2025.03205

Reconstructive Surgery–Global Open, 5(9), e1454. https://doi.org/10.1097/gox.0000000000001454

Conrad KP. (2004). Mechanisms of renal vasodilation in pregnancy: studies in chronically instrumented conscious rats. Hypertension. 43(2): 198–205.https://doi.org/10.1161/01.HYP.0000114429.30530.38

Du, H., Zhang, X., Song, G., Bao, F., Zhang, Y., Wu, W., & Liu, P. (2023). Retinal blood vessel segmentation by using the MS-LSDNet network and geometric skeleton reconnection method. Computers in Biology and Medicine, 153, 106416. https://doi.org/10.1016/j.compbiomed.2022.106416

Ebert, M. L., Schmidt, V. F., Öcal, O., von Thaden, A., Dietrich, O., Popper, B., ... & Wildgruber, M. (2025). A minimally invasive animal model of atherosclerosis and neointimal hyperplasia for translational research. European Radiology Experimental, 9, 14. https://doi.org/10.1186/s41747-025-00558-1

Eke, A. C. (2022). An update on the physiologic changes during pregnancy and their impact on drug pharmacokinetics and pharmacogenomics. Journal of basic and clinical physiology and pharmacology, 33(5), 581-598. https://doi.org/10.1515/jbcpp-2021-0312

Flešárová, S., & Maženský, D. (2016). Dorsal Branches of Abdominal Aorta in the Rabbit and the European Hare. FOLIA, 60(2), 24-28. https://doi.org/10.1515/fv-2016-0014

Fournier, S. B., D'Errico, J. N., & Stapleton, P. A. (2021). Uterine vascular control preconception and during pregnancy. Comprehensive Physiology, 11(3), 1871-1893. https://doi.org/10.1002/cphy.c190015

Granata, A., Fiorini, F., Andrulli, S., Logias, F., Gallieni, M., Romano, G., ... & Fiore, C. E. (2009). Doppler ultrasound and renal artery stenosis: An overview. Journal of ultrasound, 12(4), 133-143.https://doi.org/10.1016/j.jus.2009.09.006

Hasso, A. A. (2022). Anatomical study of arterial blood supply of the brain in local breed rabbit. https://doi.org/10.33899/ijvs.2021.129231.1636

Kremkau, F. W. (2015). Diagnostic Ultrasound: Principles and Instruments. 9th ed. Elsevier.

Lazim, E. H., & Al-Watar, B. D. (2025). Ultrasonographic detection of fetal sexing in nanny goat. Iraqi Journal of Veterinary Sciences, 39(1): 1-7. https://doi.org/10.33899/ijvs.2024.153995.3915

Maslak, S. H., and J. G. Freund. (1991). Color Doppler instrumentation. In Vascular imaging by color Doppler and magnetic resonance. Berlin, Heidelberg: Springer Berlin Heidelberg. 87-123. https://doi.org/10.1007/978-3-642-76194-2_4

Mazensky D, Flesarova S.(2017). Arrangement of renal arteries in guinea pig. Anat Rec.300(3):556-559. https://doi.org/10.1002/ar.23496

DJVS
Diyala Journal for Veterinary Sciences
مجلة ديالى للعلوم البيطرية

P-ISSN: 2410-8863
E-ISSN:2958-6178
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Pages: 55-67

Diyala Journal for Veterinary Sciences
Vol. 3 No.2 June (2025)

https://doi.org/10.71375/djvs.2025.03205

Naser R, Khaleel IM. (2020). The Arterial Vascularization of the Small and Large Intestine in Adult Male Turkeys (Meleagris gallopavo). Iraqi J Vet Med.44(E0):69-74. https://doi.org/10.30539/ijvm.v44i(e0).1024.

Noor Assim Farhan, & Ahmed Abdulla Hussein. (2024). Morphometric Comparative Study of the Pancreas between the Owl Bird and the Moorhen Bird. Diyala Journal for Veterinary Sciences, 2(3): 75–83. https://doi.org/10.71375/djvs.v2i3.215

Özdemir V, Demirkan AC, Akosman MS. (2013). Subgross and macroscopic investigation of the coeliac artery in the chinchilla (chinchilla lanigera). Folia Morphol.72(3):258–262. https://doi.org/10.5603/FM.2013.0041 40.

Parikh, N. I., Gonzalez, J. M., Anderson, C. A., Judd, S. E., Rexrode, K. M., Hlatky, M. A., ... & American Heart Association Council on Epidemiology and Prevention; Council on Arteriosclerosis, Thrombosis and Vascular Biology; Council on Cardiovascular and Stroke Nursing; and the Stroke Council. (2021). Adverse pregnancy outcomes and cardiovascular disease risk: unique opportunities for cardiovascular disease prevention in women: a scientific statement from the American Heart Association. Circulation, 143(18), e902-e916. https://doi.org/10.1161/cir.0000000000000961

Pérez-Cruz, J. C., Macías-Duvignau, M. A., Reyes-Soto, G., Gasca-González, O. O., Baldoncini, M., Miranda-Solís, F., ... & Encarnacion Ramirez, M. D. J. (2024). Latex vascular injection as method for enhanced neurosurgical training and skills. *Frontiers in surgery*, *11*, 1366190. https://doi.org/10.3389/fsurg.2024.1366190

Podomow C, August P. (2005). Renal hemodynamic alterations in pregnancy. Am J Kidney Dis. 46(5): 950–956.https://doi.org/10.1053/j.ajkd.2005.07.041

Popesko P, Rajtova V, Horak, J. (1990) Anatomic atlas of small laboratory animals I. 1st ed. Slovakia: Priroda, Bratislava. 255 p. 45.

Rojo Ríos, D., Ramírez Zarzosa, G., Soler Laguía, M., Kilroy, D., Martínez Gomariz, F., Sánchez Collado, C., ... & Arencibia Espinosa, A. (2023). Anatomical and Three-Dimensional Study of the Female Feline Abdominal and Pelvic Vascular System Using Dissections, Computed Tomography Angiography and Magnetic Resonance Angiography. Veterinary Sciences, 10(12), 704. https://doi.org/ 10.3390/vetsci10120704

Rusul Abdulhameed Kadhim. (2024) Ameliorative Role of Nigella Sativa Seeds and Levamisole on the Immune Response of Adult Male Rabbits. *Diyala Journal for Veterinary Sciences*, *2*(3): 98–112.DOI: https://doi.org/10.71375/djvs.2024.02310

Sanchez-Aranguren, L., & Nadeem, S. (2021). Bioenergetics adaptations and redox homeostasis in pregnancy and related disorders. Molecular and Cellular Biochemistry, 476(11), 4003-4018.

Sanyal D, Kumar A, Srivastava A, et al. (2014). Evaluation of renal arteries using Doppler ultrasonography after renal transplantation. Indian J Nephrol. 24(2): 88–92.https://doi.org/10.4103/0971-4065.127900

DJVS
Diyala Journal for Veterinary Sciences
مجلة ديالى للعلوم البيطرية

P-ISSN: 2410-8863
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Diyala Journal for Veterinary Sciences
Vol. 3 No.2 June (2025)
https://doi.org/10.71375/djvs.2025.03205

Sanyal, R., Zarzour, J. G., Ganeshan, D. M., Bhargava, P., Lall, C. G., & Little, M. D. (2014). Postoperative doppler evaluation of liver transplants. Indian Journal of Radiology and Imaging, 24(04), 360-366. https://doi.org/10.4103/0971- 3026.143898 31.

Sturgiss SE, Conrad KP. (2001). Renal hemodynamic changes in pregnancy: A review. Physiology of Reproduction. 2(1): 215–225.

Sulaiman, A. A., Naser, R. A. & Ahmed, R. A. (2025). Anatomical and three-dimensional study of the abdominal vascular system in female rabbit using dissections and ultrasound. *Iraqi Journal of Veterinary Sciences*, *39*(1):185-192. https://doi.org/10.33899/ijvs.2025.155920.4053

Thrall DE. (2017). Textbook of Veterinary Diagnostic Radiology. 7th ed. Elsevier.

Vargas, A. I., Tarraf, S. A., Fitzgibbons, T. P., Bellini, C., & Amini, R. (2023). Biomechanical remodeling of the murine descending thoracic aorta during late-gestation pregnancy. Current Research in Physiology, 6: 100102. https://doi.org/10.1016/j.crphys.2023.100102

Wang, F., Jin, P., Feng, Y., Fu, J., Wang, P., Liu, X., ... & Feng, X. (2021). Flexible Doppler ultrasound device for the monitoring of blood flow velocity. Science advances, 7(44): eabi9283. https://doi.org/10.1126/sciadv.abi9283

Zotti A, Rossoni A, Bernardini D, Ricci R. (2010). Ultrasound anatomy of the rabbit liver and biliary system. Vet Radiol Ultrasound. 51(4):413–420. https://doi.org/10.1111/j.1740-8261.2010.01688.x