



# Features of the Ways and Branching the Sinus Veins of the Heart of Anglo-Nubian Breed Goats in Age Aspect

VICTOR KHVATOV\*, MIKHAIL SCHIPAKIN

*St. Petersburg State University of Veterinary Medicine, 5 Chernigovskaya St., St. Petersburg, 196084, Russia.*

**Abstract** | This study provides information about features of the ways and branching of the central sinus veins of the heart of the goats of the Anglo-Nubian breed. There was studying morphometric data of the large and medium heart veins in the studied animals in the age aspect. The study carried out in three age groups: newborn animals 10-14 days; sexually mature individuals 6-7 months; one-year-old goats 12 months and older. The age was determined by scorecards, by the conclusion of the veterinary specialist of the farm "Gzhel Compound" and by the dental formula corresponding to the methods of Professor Kalugin II (1924). There were examining a total of 25 animals. Studying features of ways and branching the sinus veins of the heart of Anglo-Nubian goats using X-ray diffraction, the manufacture of corrosive and enlightened preparations. The sinus veins of goats of the Anglo-Nubian breed are the large and middle heart veins. Each of them independently flows into the coronary sinus, which located ventral to the right atrium of the heart. The large cardiac vein begins with two distal lateral branches in the lower third of the paraconal interventricular sulcus. The length of the large heart vein in mature individuals compared with newborns increases by 1.3 times, and in one-year-old individuals compared with mature ones, 1.1 times. The diameter of the large cardiac vein also increases 1.6 times in the adult, and 1.01 times in the one-year-old. The middle heart vein formed by two branches, one of which is direct from the wall of the left ventricle, and second from anastomosis with branches of the large cardiac vein located in the region of the notch of the apex of the heart. The length of the average heart vein in sexually mature goats compared with newborns increases by 2.94 times, while in one-year-old goats compared with sexually mature ones, it practically does not increase. The diameter of the middle heart vein in the age aspect in goats indicates that in sexually mature individuals, it increases by 1.3 times and in year-olds by 1.06 times. The morphometric data obtained in this study suggest that the growth rate of sinus veins after the maturity of the individuals studied by us is rapidly decreasing.

**Keywords** | Goats, Heart, Vascularization, Heart veins, Coronary sinus

**Received** | June 29, 2020; **Accepted** | July 15, 2020; **Published** | August 10, 2020

\***Correspondence** | Victor Khvatov, St. Petersburg State University of Veterinary Medicine, 5 Chernigovskaya St., St. Petersburg, 196084, Russia; **Email:** solzeworot@gmail.com

**Citation** | Khvatov V, Schipakin M (2020). Features of the ways and branching the sinus veins of the heart of Anglo-Nubian breed goats in age aspect. *Adv. Anim. Vet. Sci.* 8(10): 1057-1062.

**DOI** | <http://dx.doi.org/10.17582/journal.aavs/2020/8.10.1057.1062>

**ISSN (Online)** | 2307-8316; **ISSN (Print)** | 2309-3331

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## INTRODUCTION

The cardiovascular system is one of the most important in the animal's body and performs such functions as transport, integrative, protective, regulation of homeostasis, etc. Studies of the cardiovascular system and, in particular, the heart is relevant and significant in domestic and foreign morphology. Therefore, determination of the features of the ways and branching the sinus veins of the heart in the aspect of the pedigree anatomy of domestic animals are

of particular interest. The data obtained can be used in the form of anatomical markers in such scientific fields as veterinary cardiology, veterinary surgery, as well as in visual diagnostics (Balabanova et al., 2019).

There are three main directions for the outflow of venous blood from the myocardium of the heart. These are the sinus veins, the anterior cardiac veins, and the Tebesia-Viessen veins (Zelenevsky et al., 2016; Genain et al., 2018).

The sinus veins of the heart in domestic animals include the large, middle, and left marginal veins. According to some authors, in the goat, the coronary venous sinus opens large and medium heart veins. The last of them run parallel to the subsinuous interventricular branch of the left coronary artery in the groove of the same name (Chaplygina et al., 2013; Schipakin et al., 2015; König and Libich, 2004).

In a significant amount of work, it indicated that the average cardiac vein in goats ends on the ventral surface of the coronary sinus and formed by the subsinuous interventricular venous trunk. Which, in turn, arises from branches starting from the myocardium of the left ventricle in the region of the notch of the apex of the heart. The large cardiac vein arises from the interventricular paraconal venous trunk. Which is formed by two distal collateral branches in the distal third of the paraconal interventricular sulcus. After exiting the paraconal interventricular sulcus, the paraconal interventricular vein continues caudally as an enveloping branch. It opens into the coronary sinus at the level of the junction of the left unpaired vein (Barszcz et al., 2019; Besoluk and Tipirdamaz, 2001; Büll and Martins, 2002; Frandson et al., 2009; Smodlaka et al., 2009).

## MATERIALS AND METHODS

Studies of the obtained material were carried out at the Department of Animal Anatomy of the Federal State Budgetary Educational Establishment of Higher Education "St. Petersburg State University of Veterinary Medicine" during 2019 - 2020.

As cadaver material, Anglo-Nubian goats were used, obtained during slaughter from the Gzhel Compound farm in the Moscow Region, and delivered to the Department of Animal Anatomy.

For studying features of the ways and branching sinus veins of the heart of Anglo-Nubian goats, carried out a set of measures which included: X-ray diffraction, the manufacture of corrosive preparations using non-shrink plastic masses of the acrylic series, and the production of enlightened preparations according to the method of as modified by Zelenevsky and Schipakina (2016) with a vascular injection of black soot on gum turpentine with the addition of ethyl ether.

The study carried out in three age groups: newborn animals 10-14 days; sexually mature individuals 6-7 months; one-year-old goats 12 months and older.

The age was determined by scorecards, by the conclusion of the veterinary specialist of the farm "Gzhel Compound" and by the dental formula corresponding to the methods of Professor Kalugin I.I. There was examining total of 25 animals.

Corrosion preparations made using plastic "Redont-3" according to the method developed by morphologists "Omsk State Agrarian University named after P.A. Stolypin" under the guidance of Professor Honin G. A. in the modification of Prusakov et al. (2016, 2017).

Research methods and the number of animals studied by the age groups presented in Table 1.

For this, one part of the dry substance dissolved in two parts of the solvent. To make a strong preparation, the solution stirred with a glass rod within two minutes, and then the resulting mass by syringe injected through the cannula into the aortic bulb. Because the polymer "Redont-03" quickly solidifies in a syringe and cannula, it injected rapidly under pressure. After injection of the plastic mass, the material was fixed in a 10% formalin solution for a week, then simmered for one hour. Subsequently, the preparations corroded in an aqueous solution of potassium hydroxide (diluted 1: 2) for 4-10 days. During the corrosion treatment, the preparations were periodically washing in running water to better clean the polymer print from lysed surrounding tissues. During processing, all soft tissues under the action of potassium hydroxide dissolve only a polymer imprint of the cavities of the test object remains.

Before carrying out the method of X-ray diffraction, the cadaver material heated in a water bath at a temperature of 50 °C for 4-5 hours. Then the next stage of preparation for the study was abdominal aortic catheterization. To access it, the corpse of an Anglo-Nubian goat laid on the right side, and the abdominal wall was opened, making a transverse incision behind the convex edge of the last rib. Then, the vascular bed was washed with a 0.5% solution of ammonia until blood clots completely disappeared from the opened veins. A radiopaque mass for injections was prepared according to Chumakov V. Yu. in the modification of Zelenevsky (2013): Equal parts lead minium, liquid paraffin, turpentine + ethyl ether + ethyl alcohol; Iron minium - 15%, glycerol 40-60%, ethyl alcohol + ethyl ether - up to 100%; and Shchepakina and Prusakov (2013), consisting of lead whitewash - 45.0%, gum turpentine - 45.0% and gypsum powder - ten%.

By combining the methods, the arterial bed of the studied Anglo-Nubian goats filled by V.Yu. Chumakova mass, and K.I. Kulchitsky, with venous mass modification by N.V. Zelenevsky. Thus, in the obtained X-ray diffraction patterns, it is possible to distinguish the vessels of the arterial bed from the venous one, since the molecular mass of the iron minium (~ 160) is almost five times less than the same indicator for lead and, accordingly, absorbs X-rays to the least extent.

**Table 1:** Characterization of the test material.

Methods	Number of animals studied by age groups			
	Newborns 10-14 days	Mature 6-7 months	Yearly 12 months and older	Total investigated
Injection of vessels and manufacture of corrosive preparations	2	3	4	9
Vascular injection and the production of enlightened drugs	2	3	3	8
X-ray diffraction	3	2	3	8
Total	7	8	10	25

**Table 2:** Age-related changes in the large cardiac vein of the goat of the Anglo-Nubian breed, mm.

No.	Length			Diameter		
	Newborns	Sexually mature	Yearlings	Newborns	Sexually mature	Yearlings
1	81.56	112.57	125.14	4.95	8.26	8.35
2	81.32	112.84	125.05	4.96	8.25	8.36
3	81.96	112.17	124.85	4.94	8.24	8.37
4	81.53	111.98	124.94	4.94	8.24	8.38
5	81.67	112.67	124.87	4.95	8.25	8.35
6	81.15	112.35	125.03	4.96	8.25	8.36
7	81.74	112.86	125.11	4.95	8.26	8.36
8	-	112.54	124.97	-	8.24	8.37
9	-	-	124.88	-	-	8.35
10	-	-	125.08	-	-	8.38
Mean	81.56±8.28	112.62±11.31	124.99±12.58	4.95±0.56	8.25±0.845	8.36±0.827

When preparing the radiopaque mass according to the recipe, [Shchipakina and Prusakov \(2013\)](#), gypsum powder introduced into the mixture of liquid components with a thin stream. Then the resulting mass was thoroughly mixed within 20 to 30 minutes until a homogeneous suspension with a viscosity similar to blood plasma. The features of this technique are the fact that the resulting composition must be using immediately, and powder of medical gypsum must be sieving through a sieve before use. The advantage of this mass is that it quickly penetrates the blood vessels, including the terminal bed, and the vascular x-ray diffraction pattern shows a bright, clear, and contrasting shadow.

After injection of the x-ray with a contrasting mass, the cadaver material was placed for 5-7 days in a 10.0% formaldehyde solution for the best penetration of the introduced suspension into its terminal bloodstream.

X-ray diffraction of the injected preparations carried out under the following technical conditions: current strength 50 mA, the voltage on the tube 35 kV, focal length up to 50-60 cm, exposure time up to 2-3 seconds. Life-size photo-prints were taken from the x-ray programs, scanned and processed in the RadiAnt electronic program on a PC.

For the manufacture of enlightened preparations, a 3.0% mascara gelatin solution or colloidal charcoal used as a

contrasting mass. Due to the finely dispersed properties of the contrast mass, not only extra organic arteries and veins, but also blood vessels are forming the microcirculatory bed, filled on the studied preparation.

For a more detailed study of the organization of the microcirculatory system, enlightened preparations made according to the Shpaltegolts method V. modified by using concentrated glycerol and 2.0% KOH.

Variational-statistical processing of the research results. using the data analysis package in the program “Excel Windows Office XP” and “Statistika” 6.0” (Statsoft, USA) with a calculation of the arithmetic mean and its standard error ( $M \pm m$ ).

In the statistical analysis of the data obtained, the Student t-test was used for independent samples, while differences at  $p < 0.05$  were considered significant.

All anatomical and histological terms correspond to the “International Veterinary Anatomical Nomenclature”, fifth edition, translation and Russian terminology of Professor [Zelenevsky \(2013\)](#); “International Histological Nomenclature”



In the right atrium of goats of the Anglo-Nubian breed, there is a coronary sinus, into which the ducts of the large and medium heart veins open. The coronary sinus located on the interatrial septum ventral to the oval fossa. A similar point of view shared by Pomansky (2008).

A large cardiac vein is formed in goats of the Anglo-Nubian breed by the combination of two distal lateral branches in the lower third of the paraconal interventricular sulcus. One of these branches departs from the anastomosis with branches of the middle cardiac vein in the region of the notch of the apex of the heart, while the second formed in the area of the apex of the heart. In the middle of the paraconal interventricular sulcus, the large cardiac vein includes two branches from the cranial part of the interventricular septum of the left and right ventricles. Also, the proximal collateral vein of the left ventricle flows into it from the left ventricle. Venous blood from the arterial cone region also collects into the large heart vein. As soon as the large heart vein leaves the paraconal interventricular sulcus, it continues as an enveloping branch and repeats the course of the enveloping artery in the coronary groove. The enveloping branch of the large cardiac vein in the coronary sinus at the level of entry of the left unpaired vein into it ends.

The left marginal vein of the heart in goats of the Anglo-Nubian breed begins with many small branches on the left (ear) surface of the heart. Then it anastomoses with the distal lateral branch of the large cardiac vein.

Aksoy et al. (2013) and Genain et al. (2018) claim in their studies that the left marginal vein independently flows

into the coronary sinus. They are opposed by Besoluk and Tipirdamaz (2001), arguing that in Angora goats, the left marginal vein flows into the large heart vein. We also adhere to the latter point of view in our studies.

Morphometric data on the large cardiac vein of Anglo-Nubian goats in the age aspect presented in Table 2.

As can be seen from the table, the length of the large cardiac vein in mature individuals compared with newborns increases by 1.3 times, and in one-year-old individuals compared with mature ones, 1.1 times. The diameter of the large cardiac vein also increases 1.6 times in the mature, and 1.01 times in the one-year-old. A similar picture reflects the growth and development of the large cardiac vein in Anglo-Nubian goats, indicating growth retardation after puberty.

The middle heart vein in goats of the Anglo-Nubian breed independently flows into the coronary sinus, on its ventral surface. It formed by two branches: one of them goes from the wall of the left ventricle, and the second from the anastomosis with branches of the large cardiac vein in the region of the notch of the apex of the heart. Yoldaş and Nur (2012) in their work, they describe numerous anastomoses between the sinus veins of the heart, focusing on anastomosis in the region of the apex of the heart between the branches of the large and medium heart veins, which does not contradict the data of our study.

The middle heart vein is involved in the outflow of blood from the apex of the heart, the caudal wall of the left and right ventricles. Morphometric data on the mean heart vein of Anglo-Nubian goats in an age aspect presented in Table 3.

**Table 3:** Age-related changes in the average cardiac vein of a goat of the Anglo-Nubian breed, mm.

No.	Length			Diameter		
	Newborns	Sexually mature	Yearlings	Newborns	Sexually mature	Yearlings
1	27.12	79.84	80.10	2.68	3.55	3.78
2	27.14	79.83	80.09	2.69	3.56	3.79
3	27.14	79.84	80.08	2.7	3.57	3.8
4	27.13	79.85	80.09	2.68	3.57	3.8
5	27.12	79.84	80.10	2.68	3.57	3.79
6	27.12	79.84	80.08	2.69	3.56	3.79
7	27.13	79.85	80.08	2.69	3.55	3.78
8	-	79.83	80.09	-	3.56	3.79
9	-	-	80.09	-	-	3.8
10	-	-	80.08	-	-	3.78
Mean	27.13±2.68	79.84±8.12	80.09±8.08	2.69±0.34	3.56±0.38	3.79±0.41

The analysis of Table 2 indicates that the length of the average heart vein in sexually mature goats compared with

newborns is increased by 2.94 times, and in year-old goats compared to sexually mature practically does not grow. The



diameter of the middle heart vein in the age aspect in goats indicates that in sexually mature individuals, it increases by 1.3 times and in year-olds by 1.06 times. A similar picture may be due to the weak development of the middle heart vein during the prenatal period of ontogenesis, and also indicates a slowdown in the growth of the middle heart vein in goats of the Anglo-Nubian breed after puberty.

## CONCLUSION

As a result of these studies established the features of ways and branching main sinus veins of the heart of a goat of the Anglo-Nubian breed. The main sources of the formation of large and medium heart veins indicated. It found that the left marginal vein in the goat of the Anglo-Nubian breed does not have an independent connection with the coronary sinus in the right atrium of the heart. The paper shows the morphometric data of the large and medium heart veins; their length and diameter, and established decrease in the intensity of growth and development of these vessels after the maturity of individuals.

The data obtained are of specific scientific interest. They can be used in veterinary surgery and cardiology, as well as in such visual diagnostics as magnetic resonance imaging, ultrasound diagnostics, and X-ray diffraction radiography. The question remains of the study of the smallest veins of the heart and veins of Tebesia-Viessen, which indicates the need for further research.

## ACKNOWLEDGMENTS

The study was financially supported by the Russian Foundation for Basic Research as part of scientific project No. 19-316-90033.

## AUTHORS CONTRIBUTION

V.A. Khvatov: obtaining data for analysis, analyzing the data obtained, writing the text of the manuscript, reviewing publications on the topic of the article. M.V. Shchipakin: research design development; analysis of the obtained research data, scientific leadership

## CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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