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Arterial vascularization of the spleen in Merino sheep

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Abstract: In this study, it is aimed to reach detailed information about the anatomy of arteries in the sheep spleen, which can be used as an example and model for the success of planned or emergency surgical interventions related to the spleen.
In spleen injuries, the spleen may be divided into two or three parts, or it may be limited to cracks on the spleen. In particular, it is aimed to protect the organs that have been damaged by trauma recently. Operations such as splenectomy and splenography are surgical procedures that require good knowledge of the pathways of artery and its branches and segmentation of the spleen.
In our study, 30 merino sheep spleens were used. Macroscopic findings were obtained from materials given colored liquid latex from arteria lienalis and preserved in formaldehyde. In addition, artery patterns of the spleens obtained by the corrosion cast method were also used. Scanning electron microscopic images were taken and evaluated. When 30 spleens were examined in the study; arteria lienalis, we examined were divided into two main branches as arteria ventralis and arteria dorsalis. Arteria medialis extending to the avascular region was detected in 2 of 30 spleens. In only 1 of the 30 spleens, an accessory artery was observed that separated the arteria ventralis. It was examined that arteria centralis originated from arteria trabecularis. It was determined that arteriola penicillaris, which has smaller diameter arteries and where the circulation takes place, originates from arteria centralis. This is a macroscopic and scanning electron microscopic study examining the arterial distribution of the spleen in high merino sheep population in Turkey. With this aspect of the study, it is aimed to contribute to the literature.

Key words: Artery, merino sheep, scanning electron microscopy, spleen

1. Introduction

Blood flow from the spleen is very important and complex. Blood enters the spleen at the hilus via the artery lienalis. Arteria lienalis divides into trabecular arteries that enter the splenic parenchyma. The capillaries both terminate in the reticular meshwork (open circulation) and drain directly into the venous (closed circulation) sinuses. Blood is poured from the sinuses into small veins in the reticulum through small holes (stigma malpighi) in the walls. Larger veins formed by the union of these small veins are inserted into the trabeculae. After exiting the hilum, they unite to form the vena lienalis. The vena lienalis then opens into the vena portae [1]. Splenectomy, splenography, partial resection and percutaneous splenic puncture biopsy are surgical operations that require good knowledge of the pathways of blood arteries and their branches and segmentation of the spleen. These diagnostic and therapeutic operations are justified by its economic importance [2]. Studies on human and animal spleens show that arterial vascularization is of segmental type. Any lesion that does not transversely cut the segmental arteries causes a small amount of bleeding that can stop spontaneously without causing infarction. On the other hand, the total crosssection of segmental arteries lead to significant bleeding followed by a state of shock [3].

Detailed knowledge of the structural and topographic aspects of blood arteries is essential for the success of planned or emergency surgical interventions on the spleen. This study examines the anatomical variation in the terminal branching pattern of the arteria lienalis in merino sheep.

2. Materials and methods

In the study, 30 merino sheep spleens were used. Ten of the thirty materials were injected with latex, and twenty of them were given takilon for corrosion cast. Takilon (100 mL liquid monomethylmethacrylate, 21 g powder polymethylmethacrylate and 8 g red dye), used for the corrosion cast method, was given from arteria lienalis. For maceration of the samples, they were kept in an oven at 35–40 °C in 5% KOH solution [4]. For scanning electron microscopic images, after the materials were removed from

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soft tissue, 0.5 cm^2 pieces were carefully cut and covered with gold first. Images were taken and measurements were made. SEM-JEOL (JCM 5000) was used for SEM images. Since the materials used are products from slaughterhouses, there is no need for an ethics committee document.

3. Results

It was determined that arteria lienalis, which is the main artery of the spleen, entered the spleen tissue only through the hilus lienis. Arteria lienalis; it was found that after entering the spleen from the hilus lienalis, it gave small branches to the ventral and dorsal sides just before dividing into the main branches. On average, three branches were observed in the dorsal part and two branches in the ventral part (Figure 1). We divided into two main branches as arteria ventralis and arteria dorsalis of arteria lienalis (Figure 1). It was seen that these branches formed an inverted reverse "Y" shape. While arteria dorsalis keep going in extremitas dorsalis, arteria ventralis was found to be in margo caudalis. Arteria medialis was seen in 2 of 30 spleens, feeding the region called avascular region extending to extremitas ventralis and lower 1/3 of extremitas dorsalis (Figure 2). In only 1 of the 30 spleens, an accessory artery (Figure 3) branching before the arteria dorsalis was observed. Arteria dorsalis; it was determined that it was in the form of a continuation of the arteria lienalis.

Hilus lienalis was seen to be located on the visceral aspect of the spleen. The diameters of arteria lienalis after entering from the hilus lienalis were measured and averaged, and it was determined as 4.8 mm. It was observed that arteria dorsalis was longer than arteria ventralis. The mean length of arteria dorsalis was found to be 51.2 mm. The mean of arteria ventralis was 26.2 mm. It was determined that the part of the spleen, defined as avascular, was not fed by an extra arm in 93% of the samples we examined, and this region was usually supplied by the first trabecular artery originating from the dorsal artery of the arteria ventralis and the first and second trabecular arteries emerging from the ventral of the arteria dorsalis. Arteria medialis (Figure 2), which directly feeds the avascular region, was determined in only two of the spleens we examined. It was observed that this artery originated from the arteria lienalis and was initially 21.4 mm in diameter.

After arteria lienalis was divided into two branches in general, arteria trabecularis were found to originate from these branches. Arteria ventralis has an average of five as dorsally and two as ventrally. It was observed that it separated into arteria trabecularis. It was defined that the arteria ventralis was divided into five arteria trabecularis

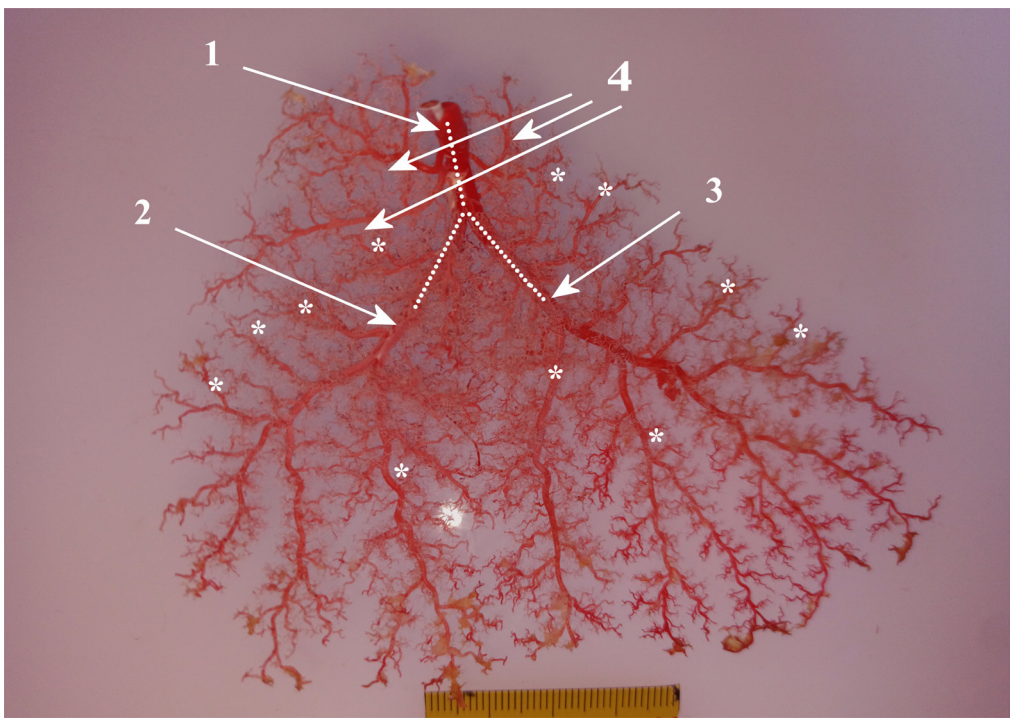

Figure 1. View of the arteries of spleen with the corrosion cast method. Asterisks: A. trabecularis, 1. A. lienalis, 2. A. ventralis, 3. A. dorsalis, 4. Dorsal and ventral branches of arteria lienalis that separate before dividing into two main branches, dotted line: reverse "Y" view.

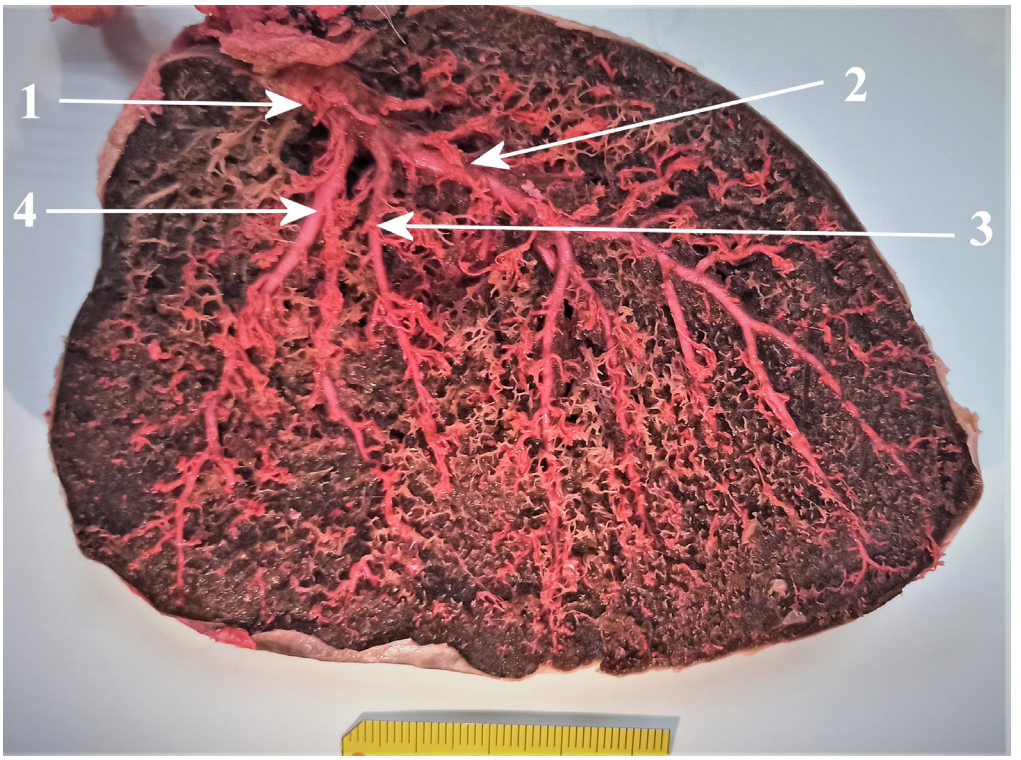

Figure 2. 1. Arteria lienalis, 2. Arteria dorsalis, 3. Arteria medialis, 4. Arteria ventralis.

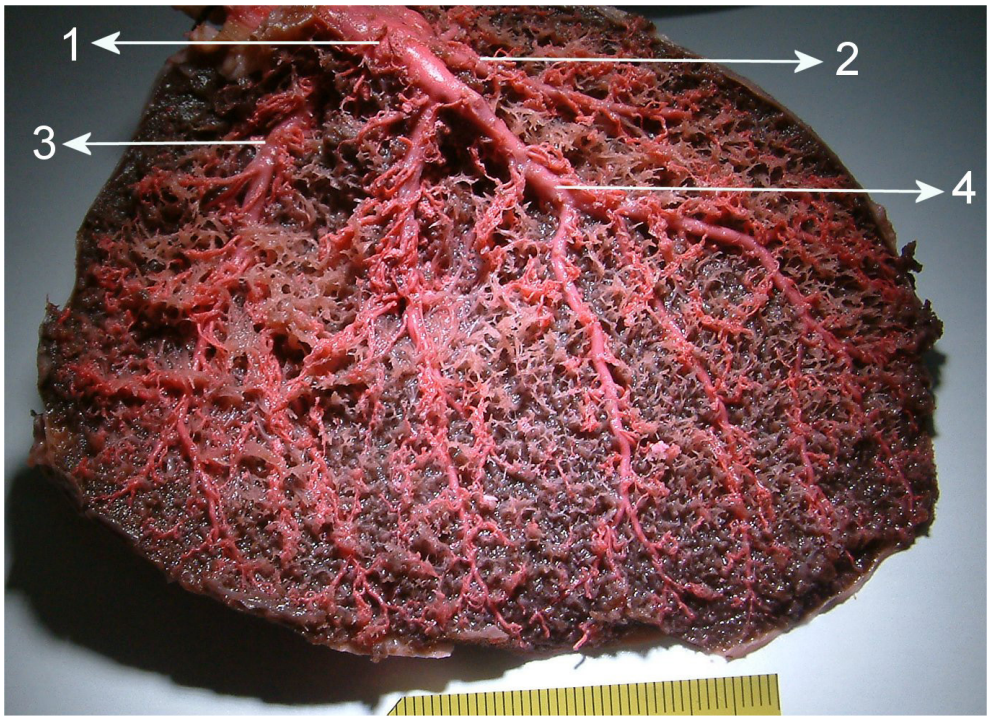

Figure 3. View of latex-filled arteries and also accessory artery. 1. Arteria lienalis, 2. Accessory artery, 3. Arteria ventralis, 4. Arteria dorsalis.

dorsally and two ventrally. It was identified that the arteria dorsalis was divided into an average of six arteria trabecularis dorsally and two arteria trabecularis ventrally.

The diameters of the arteria trabecularis were measured and averaged between 0.5 mm and 1.6 mm. It was observed that the diameter of arteria trabecularis (Figure 4) became thinner as it progressed to the extreme points.

Arteria trabecularis was separated into arteria centralis, and then it was determined that brush arterioles (arteriola penicillaris) emerged in the form of many branches extending side by side from arteria centralis (Figure 5).

The diameter of arteria trabecularis was measured in the range of 196 – 653 µm.

Arteria centralis, after leaving the arteria trabecularis, has been guessed that the cylindrical lymphoid tissue sheath moved down the axis of the vagina periarterialis lymphatica (PALS, PALS tissue could not be seen in the study). The diameters of the arteria centralis were measured in the range of 40 to 75 µm. Arteriola penicillaris, which extend to the red pulp and marginal region after the arteria centralis and join the main circulation, were detected. The diameter of arteria centralis was measured in the range of 40 to 75 µm. At the same time, it was observed that this diameter value decreased to 2 to 3 µm in the last parts of arteriola penicillaris. After separating from arteria centralis, arteriola penicillaris were seen to end by branching again. While some of the vascular endings of these arterioles were enlarged and ended in the form of a bulb it was observed that some of them ended in a more pointed way (Figure 5).

The diameters of the bulb-shaped ends were measured between 21 µm and 62 µm. At the same time, bubble appearances were detected on the artery surface near the end (Figures 6 and 7). Their diameters were measured from 15 to 60 µm.

In the artery face, nucleus traces were observed as seen in Figure 8.

4. Discussion

Arteria lienalis that emerged arteria dorsalis and arteria ventralis was detected. It was determined that these branches were seen in extremitas dorsalis and margo caudalis. Therefore, tears in these areas will cause more blood loss. Redmond et al. [5] also mentioned in his study on the human spleen that it divides into two lobar branches, arteria superior and inferior, and that a third lobar artery is not registered. Liu et al. [6] in 850 human spleen samples, spleen with single lobar artery in five cases (0.8%), spleen

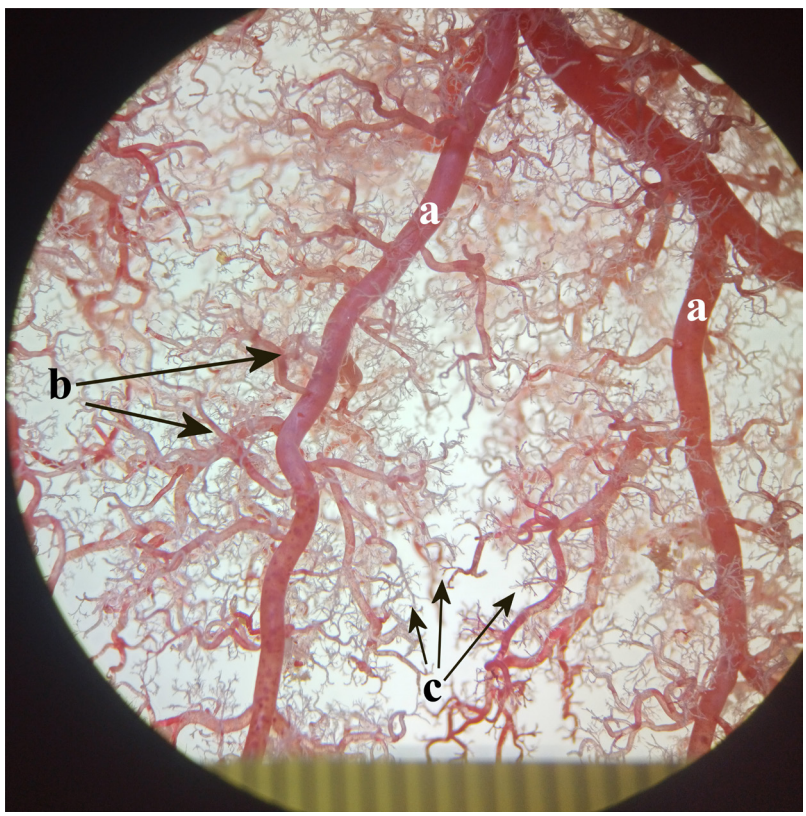

Figure 4. Stereomicroscopic view, a. Arteria trabecularis, b. Arteria centralis, c. Arteriola penicillaris.

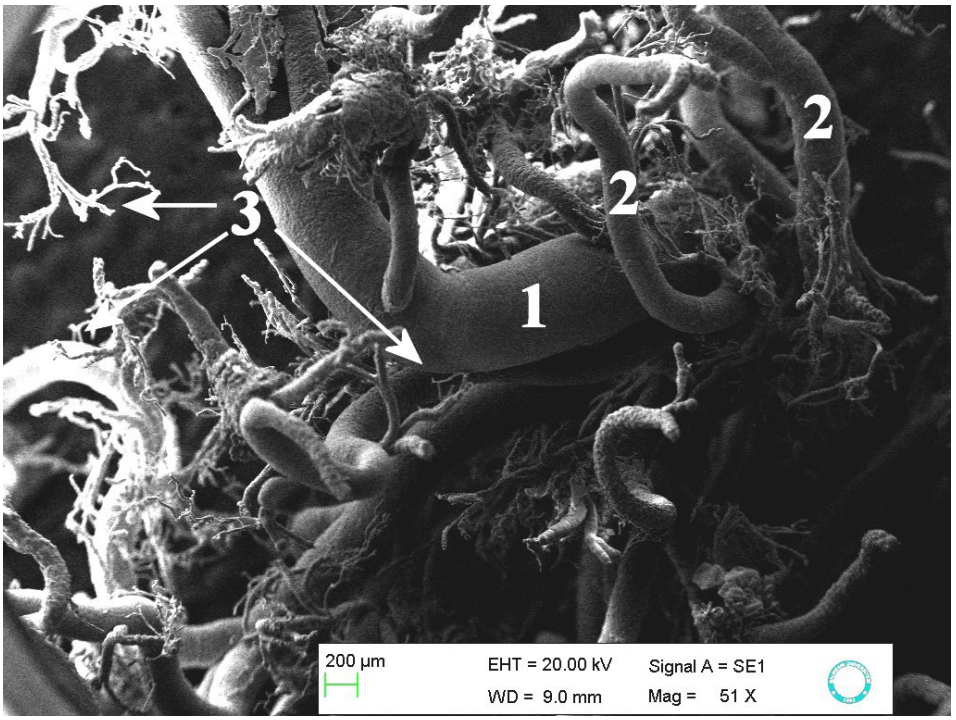

Figure 5. Scanning electron microscopic view, 1. Arteria trabecularis, 2. Arteria centralis, 3. Arteriola penicillaris.

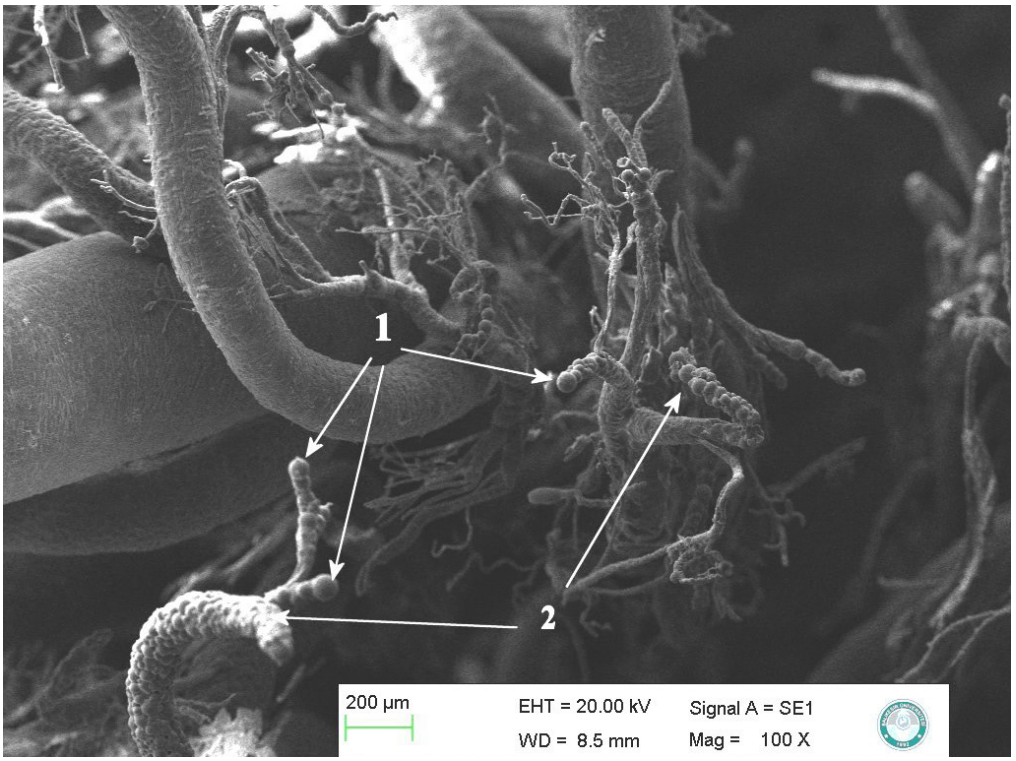

Figure 6. 1, 2: The bulb-like ending and bubble appearance of arteria penicillaris.

Figure 7. Asterisks: The bulb-like ending appearance of arteria penicillaris.

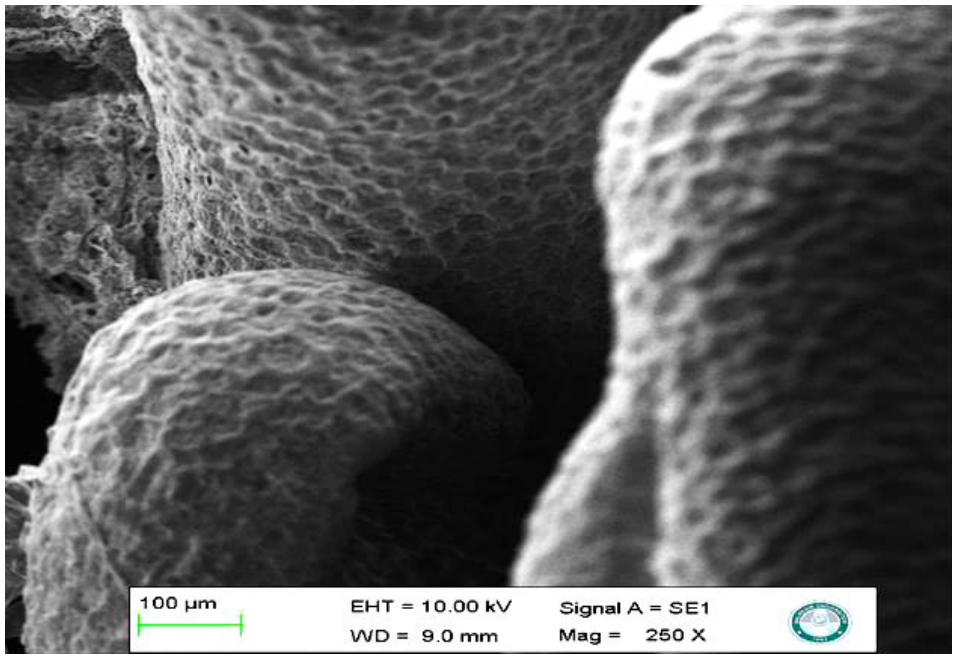

Figure 8. The appearance of the nucleus traces of the cells forming the artery.

with two arteries in 730 cases (86%), spleen with three lobar arteries in 104 cases (12.2%), and spleen with three lobar arteries in 9 cases (1%) identified spleens with more than three lobar arteries. In another study, in 70% of cases observed the division of the arteria lienalis into a "Y" shape [7]. In our study on merino sheep, an arterial distribution similar to the human spleen was observed. At the same time, in the majority of the spleen of the merino sheep, as in humans, the arteria lienalis followed the path by dividing into an inverted "Y" shape after entering from the hilus lienalis. Gupta et al. [8] mentioned the presence of small branches in the hilus lienalis immediately after its entry. In the study, ventral and dorsal small branches were identified before dividing into main branches. In a study, the arteria lienalis vasculature of camels [9] was examined and it was found that the arteria lienalis divided into two branches after the hilus. In the study conducted by Nawal et al. [10], they mentioned that the camel spleen is divided into 3 branches as cranial, middle and caudal artery segments. In the study of Bennoune and Al-Samarrae [2] on 25 camel spleens, they found that 84% of the vascularization of the spleen was provided by two branches of the arteria lienalis of different sizes. They observed three branches in 12%, whereas they observed four branches in only 4% of cases. In the study, after arteria lienalis, it was observed that 93% split into two branches as dorsal and ventral, and 7% divided into three branches.

In the study of Rashad et al. [11] on buffalo spleen, they mentioned that the arteria lienalis of the buffalo spleen is divided into three main branches as dorsal, middle and ventral. The dorsal branch extends caudodorsally about 2–3 cm in the parenchyma and divides into two branches, which in turn divide into other branches. The ventral branch was considered as a direct continuation of the arteria lienalis, while the intermediate branch separated as the dorsal branch feeding the middle segment. The ventral branch of the spleen gave off cranial and caudal branches. It had 10–12 branches extending in the cranioventral direction to branch in the relevant part of the organ. The caudal branches are involved in the feeding of the first branch of the middle segment, while the numbers range from 8 to 10. In our study, arteria lienalis, after dividing into two main branches as ventral and dorsal, trabecular arteries with smaller diameters were observed, emerging from these branches and advancing within the trabecular. It was noted that the arteria ventralis was divided into five trabecular arteries dorsally and two ventrally. It was observed that the arteria dorsalis was divided into six trabecular arteries in the dorsal and two trabecular arteries in the ventral.

In the study of Wally and Gad [12] on goats, they mentioned that after entering from the hilus lienalis, the arteria lienalis splits into two branches, giving small tree-like branches oriented cranially and caudally into the spleen parenchyma observed that one of them divides into approximately 6–8 cranial branches and 5–7 caudal branches. In this study on Merino sheep, goats were similar in terms of trabecular branching.

Microvascular patterns were revealed by corrosion casting. It has been mentioned that the arterial structure in sheep is formed by syncytium with a sieve-like core, large stomata and a less pronounced longitudinal orientation [13]. In the study, nucleus traces were observed as seen in Figure 8. The average core diameter was found to be 22 μm. Arteria trabecularis was separated into arteria centralis, and then brushed arterioles (arteriola penicillaris) emerged in the form of many branches extending side by side from arteria centralis.

With the scanning electron microscope, especially the vascular structures and the arteria penicillaris, where the circulation takes place, were examined.

The diameter of the trabecular arteries was measured between 220 μm and 612 μm. When we measured the diameter of arteria centralis, values between 42 μm and 75 μm were found. In a study conducted in dog spleen [14], the diameters of arteria centralis were found to be 40–60 μm, which is close to the findings of our study. After the arteria centralis the red pulp that looks like tree branches and the diameter of the arteria penicillaris extending to the marginal region were measured between 5 μm and 12 μm. In human spleens, this value was found to be between 7 μm and 10 μm. [15]. In the measurements (Figure 5), it was observed that the diameters of the arteria penicillaris narrowed to 2–3 μm. The fact that some vessel endings are measured as 2–3 μm confirms the adequacy of plastic perfusion penetrating the smallest vessels [15]. However, in the study, it was also observed that the diameters of some arteries were enlarged and ended in the form of bulbs. It was measured that the artery diameters expanded from 20 to 30 μm. This imaging has been interpreted as a funnel-shaped pulp opening in studies on mammalian spleens. This image has been interpreted as a funnel-shaped opening in studies on mammalian spleens [16]. This region corresponds to the structures described by MacNeal et al. [17] as bulb-shaped. Schmidt et al. [14], on the other hand, mentioned that at higher magnifications, most of the arteria penicillaris terminate with expanding or trumpet-shaped blunt ends. One of the most striking findings of arterial circulation in this chapter is that in casts from both constricted and enlarged spleens, many arterioles and arterial capillaries terminate blindly and cannot always be traced to their termination. They explained that these "blind ends" can occur not only as a result of too little material being injected into the tissue, but also by dense filling of nearby structures [14]. Pinhead-shaped blisters were observed on the arteria penicillaris

seen in Figures 6 and 7. Barnhart et al. [15] explained the reason for this appearance as occlusion of the arterioles when the spheres are too narrow to allow passage.

As a result, arteria medialis was observed in addition to arteria ventralis and dorsalis in 2 of 30 spleens. In only 1 of the 30 spleens, an accessory artery branching before the ramus dorsalis was observed. In only 2 of the spleens we examined, it was noticed that direct blood supply to the avascular region was provided by the arteria medialis. In other spleens, it was observed that most of the blood supply of the avascular region of the spleen was played by the arteria trabecularis originating from the arteria dorsalis. It was observed that the parietal surface of the branches of the arteria lienalis entering from the hilus lienalis was also blooded by arteria trabecularis extending from these main branches. It was seen that arteria trabecularis separated into arteria centralis and then originated from arteriola penicillaris, which are smaller diameter vessels extending from arteria centralis and where circulation is actualized. When examined with a scanning electron microscope, it was determined that the vascular endings of some arteriola penicillaris had a large bulb-shaped end. In animals, ruptures occur in sudden movements when the spleen is tense and brittle due to trauma or diseases that cause splenomegaly. In spleen ruptures, the spleen may be divided into two or three parts, or it may be limited to cracks on the spleen. Depending on the size of the injury, surgical methods such as splenography to preserve organ integrity should be preferred instead of splenectomy. It is necessary to have detailed information about the paths of blood vessels and their branches and the segmentation of the spleen in order to be able to intervene quickly with the successful application of these methods.

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Informed consent
The study protocol was approved by the Ethics Committee Balıkesir University.

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