Cilt 11, Sayı 1, Sayfa 102-107, 2022 Volume 11, Issue 1, Page 102-107, 2022

Araştırma Makalesi https://doi.org/10.46810/tdfd.1013782 Research Article

Türk Doğa ve Fen Dergisi
Turkish Journal of Nature and Science
www.dergipark.gov.tr/tdfd

A Macroanatomic Study on Coronary Arteries and its Branches in Southern Karaman Sheep: Corrosion Casting Technique and Latex Method

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(Received: 23.10.2021, Accepted: 10.02.2022, Online Publication: 25.03.2022)

Keywords
Anatomy, Southern Karaman sheep, Coronary artery, Corrosion casting, Latex

Abstract: This study was carried out to reveal the coronary arteries and their branches that provide vascularization of the heart in Southern Karaman sheep. Eight Southern Karaman sheep were used in the study. The coronary arteries and their branches providing arterial vascularization of the heart were determined using latex injection and corrosion casting technique. Arteria coronaria sinistra and its branches were observed to be more dominant than arteria coronaria dextra. It was determined that after the origin of arteria coronaria sinistra, it splits into two main branches as ramus interventricularis paraconalis and ramus circumflexus sinister. It was determined that arteria coronaria dextra continued on its way as ramus circumflexus dexter after reaching the sulcus coronarius and gave branches to ensure the vascularization of the region tissues. This study aimed to reveal the coronary arteries and their branches in Southern Karaman of Turkey's domestic sheep breeds, and it is thought that it will contribute to new studies on this breed.

Güney Karaman Koyunlarında Koroner Arterler ve Dalları Üzerine Makroanatomik Bir Çalışma: Korozyon Kast Tekniği ve Lateks Yöntemi

Anahtar Kelimeler
Anatomi, Güney Karaman koyunu, Koroner arter, Korozyon kast, Lateks

Öz: Bu çalışma Güney Karaman koyununda kalbin vaskularizasyonunu sağlayan koroner arterler ve dallarının ortaya çıkarılması amacıyla yapıldı. Çalışmada 8 adet Güney Karaman ırkı koyun kullanıldı. Lateks enjeksiyon ve korozyon kast teknikleri kullanılarak kalbin arteriyel vaskularizasyonunu sağlayan koroner arterler ve dalları belirlendi. Arteria coronaria sinistra ve dallarının arteria coronaria dextra'ya göre daha dominant olduğu gözlendi. Arteria coronaria sinistra'nın orijininden sonra ramus interventricularis paraconalis ve ramus circumflexus sinister olarak 2 ana dala ayrıldığı belirlendi. Arteria coronaria dextra'nın ise sulcus coronarius'a vardıktan sonra yoluna ramus circumflexus dexter olarak devam ettiği ve seyri esnasında bölge vaskularizasyonunu sağlamak üzere dallar verdiği tespit edildi. Bu çalışmada Türkiye'nin yerli koyun ırklarından biri olan Güney Karaman koyununda koroner arterler ve dalları ortaya konulmaya çalışılmış olup, çalışmanın bu ırk üzerine yapılacak olan yeni çalışmalara katkı sağlayacağı düşünülmektedir.

1. INTRODUCTION

The Southern Karaman sheep is a separate breed formed as a result of crossbreeding Karagül rams with Akkaraman and Dağlıç sheep brought by the nomads (Türkmen) who migrated from Türkistan to the Mediterranean during the Ottoman period. Southern Karaman Sheep is highly productive in terms of meat and milk and is a frequently preferred breed inbreeding [1,2].

The heart is vascularized by the arteria (a) coronaria dextra and arteria coronaria sinistra, which originate from the sinus aorta portion of the ascending aorta [3-7]. Arteria coronaria sinistra is more dominant in cattle [8], buffalo [9], sheep [10], and dog [11]. Arteria coronaria dextra is more dominant in goats [12], pigs [13], donkeys [14], and 90% of humans [15].

After arteria coronaria sinistra originates from the aorta, it reaches the sulcus coronarius by going downwards and slightly to the left between the truncus pulmonalis and

auricula sinistra [16,17,18]. At the level of this sulcus, it divides into two main branches: ramus circumflexus sinister and ramus interventricularis paraconalis [19,20]. The branches given by ramus interventricularis paraconalis are ramus coni arteriosi, ramus collateralis sinister proximalis, ramus collateralis sinister distalis, and rami septales during its course [21]. Ramus circumflexus sinister gives to feed atrium sinistrum ramus proximalis atrii sinistri, ramus intermedius atrii sinistri and ramus distalis atrii sinistri [7] to feed ventriculus sinister ramus proximalis ventriculi sinistri, ramus marginis ventricularis sinistri and ramus distalis venticuli sinistri [22].

Arteria coronaria dextra originates from the beginning of the aorta at the level of the valvula semilunaris dextra [7]. After reaching the sulcus coronarius, it continues as ramus circumflexus dexter [7,10,11]. During the course of the arteria coronaria dextra, it is also divided into branches as ramus proximalis atrii dextri, ramus intermedius atrii dextri, ramus distalis atrii dextri, ramus coni arteriosi, ramus proximalis ventriculi dextri, ramus marginis ventricularis dextri, and ramus distalis ventriculi [6,7]. This study aimed to reveal the coronary arteries and their branches that provide arterial vascularization of the heart in Southern Karaman of Turkey's domestic sheep breeds.

2. MATERIAL AND METHOD

The present study was admitted by Atatürk University Local Ethics Committee (2021-23). In the study, eight Southern Karaman sheep were obtained from Konya Bahri Dağdaş International Agricultural Institute to be used in the study. The arteria carotis communis in the neck region of the sheep [23] were cut under xylazine HCl (0.2 mg/kg/IV) and ketamine HCl (2.2 mg/kg/IV) anesthetized. Then, their blood was drained, and coronary arteries and their branches were washed with 0.9% physiological saline. Afterward, a latex mixture colored with red acrylic dye was applied to the coronary arteries from the ascending aorta by the latex injection method [24]. They were kept in 10% formaldehyde solution for 72 hours for fixation. The dissected coronary arteries and their branches were named based on Nomina Anatomica Veterinaria [25] and photographed to illustrate vessels.

To create cast models of the coronary arteries, an acrylic solution prepared as 80% liquid (polymethylmetachrylate) and 20% powder (monomethylmetachrylate) was colored with red dye, which was injected from the ascending aorta. The tissues were kept in water overnight and then incubated in a 20% potassium hydroxide solution (KOH) solution at 37ºC for 24 hours. The coronary arteries and their branches, which were cast and dissected, were photographed and named based on Nomina Anatomica Veterineria [25].

3. RESULTS

The ascending aorta started from the ventriculus sinister. According to the study, it gave arteria coronaria dextra and arteria coronaria sinistra from the sinus aorta section to provide arterial vascularization of the heart immediately after its origin. It was observed that both main branches were partially intramyocardial (Figure 1, Figure 2a,c, and Figure 3a,b,c).

Compared to the arteria coronaria dextra, the arteria coronaria sinistra separated from the aorta ascendens in the section that overlaps the valvula semilunaris sinistra as a thicker root in all animals used in the study. The ramus proximalis atrii sinistri of arteria coronaria sinistra fed the atrium sinistrum shortly after its formation from the aorta ascendens. After that, the arteria coronaria sinistra split into two more main branches, the ramus interventricularis paraconalis, and the ramus circumflexus sinister (Figure 1, Figure 2a, and Figure 3a,b,c).

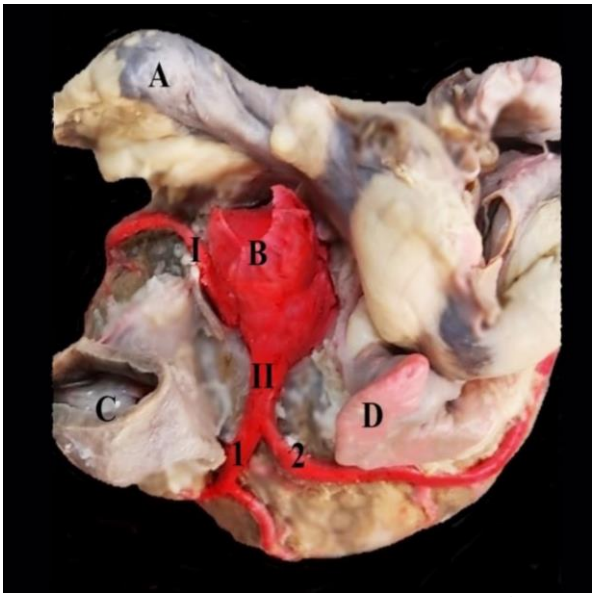

Figure 1. Aorta ascendens and its branches in the heart of the South Karaman sheep, A: auricula dextra, B: aorta ascendens, C: truncus pulmonalis, D: auricula sinistra I: arteria coronaria dextra, II: arteria coronaria sinistra, 1: ramus interventricularis paraconalis, 2: ramus circumflexus sinister.

The ramus interventricularis paraconalis first proceeded subepicardially in the sulcus interventricularis paraconalis, caudoventrally towards the apex cordis, with the vena cordis magna. It was seen that it gave branches to facies atrialis before reaching incisura apicis cordis along its path. Ramus interventricularis paraconalis gives branches towards facies auricularis. These branches are from proximal to distal; proximal branch to ventriculus sinister, ramus collateralis proximalis, distal branch to ventriculus sinister and ramus collateralis distalis. After feeding the ventriculus sinister, the ramus collateralis proximalis spread to the proximal 1/3 of the ventriculus sinister. The ramus collateralis distalis was found to be dispersed, supplying the ventriculus sinister's middle and distal 1/3. Ramus septalis, the branch it gave to feed ramus coni arteriosi, and ventriculus dexter, the branch it gave to feed the

conus arteriosus region, were the branches that ramus interventricularis paraconalis gave respectively from proximal to distal from proximal to facies atrialis after its origin. In addition to these, it was determined that ramus interventricularis paraconalis gave many rami septales branches to feed the septum interventriculare during its course (Figure 2a and Figure 3a).

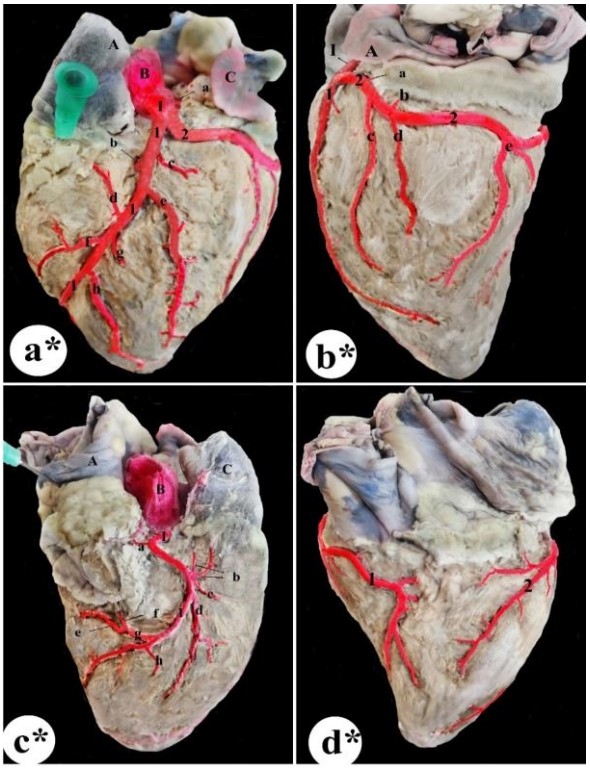

Figure 2. Branches of arteria coronaria sinistra and arteria coronaria dextra in the heart of South Karaman sheep with the latex method, a*: ramus interventricularis paraconalis and its branches; A: truncus pulmonalis, B: aorta ascendens C: auricula sinistra I: arteria coronaria sinistra, a: ramus proximalis atrii sinistri, b: ramus septalis, c: proximal branch of ramus interventricularis paraconalis for ventriculus sinister, d: ramus coni arterio , e: ramus collateralis proximalis, f: branch of ramus interventricularis paraconalis to ventriculus dexter, g: distal branch of ramus interventricularis paraconalis to ventriculus sinister h: ramus collateralis distalis, 1: ramus interventricularis paraconalis, 2: ramus circumflexus. b* ramus circumflexus sinister and its branches; A: auricula sinistra, I: arteria coronaria sinistra. a: ramus intermedius atrii sinistri, b: ramus distalis atrii sinistri, c: ramus proximalis ventriculi sinistri d: ramus marginis ventricularis sinistri,, e: ramus distalis ventriculi sinistri, 1: ramus interventricularis paraconalis, 2: ramus circumflexus sinister. c*: arteria coronaria dextra and its branches; A: auricula dextra, B: aorta ascendens, C: truncus pulmonalis, I: arteria coronaria dextra, a: ramus proximalis atrii dextri, b: ramus coni arteriosi, c: ramus proximalis ventriculi dextri, d: ramus marginis ventricularis dextri, e: ramus distalis atrii dextri, f: ramus intermedius atrii dextri, g: ramus intermedius atrii dextri ve ramus distalis atrii dextri'nin ortak kökü, h: ramus proximalis ventriculi dextri. d*: ramus interventricularis subsinuosus and ramus circumflexus dexter; 1: ramus interventricularis subsinuosus, 2: ramus circumflexus dexter.

Arteria circumflexus sinister, the other of the two main branches of the arteria coronaria sinistra, proceeded laterally on the heart's facies auricularis within the sulcus coronarius. It was observed that it provided ramus intermedius atrii sinistri to vascularize the atrium sinistrum along its dorsal surface during its course. It was discovered that it gave rise to the ramus proximalis ventriculi sinistri, a thicker branch that feeds the ventriculus sinister from the caudoventral direction. After continuing its course for a while, it was determined that one of them originated from its dorsal side and gave ramus distalis atrium sinistri to feed the atrium sinistrum. The other one, which was thicker and separated from the ventral face, proceeded in the caudoventral direction and gave ramus marginis ventricularis sinistri to feed the ventriculus sinistri. The ramus marginis ventricularis sinistri originated shortly after the margo ventricularis and spread to the proximal 1/3 of the ventriculus sinister, according to research. The ramus circumflexus sinister was observed to continue its route for a bit of time before splitting into two more branches that came from a single root on its ventral surface and proceeded in a caudoventral direction. These branches, which gradually spread up to the distal 1/3 of the ventriculus sinister, were found to be ramus distalis ventriculi sinistri. After giving all these branches, ramus circumflexus sinister tended towards caudoventrally and continued on its way as ramus interventricularis subsinuosus in sulcus interventricularis subsinuosus. In the meantime, it was observed that it gave thin side branches to feed the tissues of the region (Figure 2b,d and Figure 3b,d).

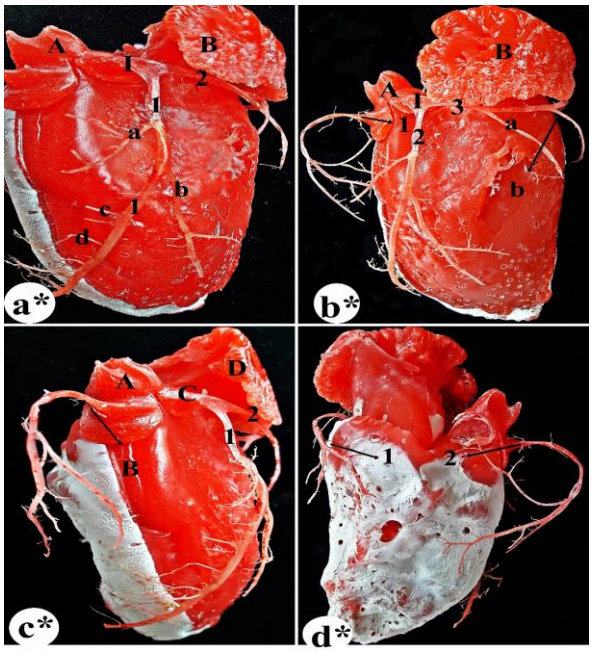

Figure 3. Branches of arteria coronaria sinistra and arteria coronaria dextra in the heart of South Karaman sheep with Corrosion Casting Technique, a*: ramus interventricularis paraconalis and its branches; A: aorta ascendens, B: auricula sinistra, I: arteria coronaria sinistra, a: ramus septalis, b: ramus collateralis proximalis, c: ramus coni arteriosi, d: branch of ramus interventricularis paraconalis to ventriculus dexter, 1: ramus interventricularis paraconalis, 2: ramus circumflexus sinister. b* ramus circumflexus sinister and its branches; A: aorta ascendens, B: auricula sinistra, I:arteria coronaria sinistra., a: ramus proximalis ventriculi sinistri, b: ramus marginis ventricularis sinistri, 1: arteria coronaria dextra, 2: ramus interventricularis paraconalis, 3: ramus circumflexus sinister. c*: arteria coronaria dextra and arteria coronaria sinistra; A: aorta ascendens, B: arteria coronaria dextra, C:arteria coronaria sinistra D: auricula sinistra 1: ramus interventricularis paraconalis, 2: ramus circumflexus sinister. d*: ramus interventricularis subsinuosus and ramus circumflexus dexter; 1: ramus interventricularis subsinuosus, 2: ramus circumflexus dexter.

It was found that arteria coronaria dextra moved between the truncus pulmonalis and the auricula dextra, originating from the aorta ascendens at the level of the valvula semilunaris dextra. It was discovered that it inclined towards the facies atrialis and passed through the sulcus coronarius, under the subepicardial adipose tissue. It continued as ramus circumflexus dexter after reaching the sulcus coronarius. The ramus proximalis atri dextri was discovered to be the thin branch that arteria coronaria dextra gave towards the dorsocranial to feed the atrium dextrum. It continued over the ventral aspect of the arteria coronaria dextra. It continued towards the facies auricularis, showing ramus coni arteriosus, which is responsible for the arterial vascularization of the conus arteriosus region and separated with ramus proximalis ventriculi dextri in two branches in five of the materials used in the study. Three branches are separated from a single root as two branches. The ventriculus dexter was fed over the caudoventral side of the arteria coronaria dextra after the ramus proximalis ventriculi dextri was separated. This branch proceeded intramyocardially in the middle levels of the ventriculus dexter, parallel to the sulcus interventricularis paraconalis. The ramus marginis ventricularis dextri was found as the branch that separated from the caudoventral of the arteria coronaria dextra and proceeded parallel to the sulcus interventricularis subsinosus to feed the ventriculus dexter. This branch proceeded across the middle 1/3 of the ventriculus dexter and had branching along the way. Ramus intermedius atrii dextri and ramus distalis atrii dextri were discovered at the level of margo ventricularis dexter to be branches that ramus circumflexus dexter gave towards dorsocranial to feed the atrium dextrum. From a common root, these two branches were split off. It was found that ramus distalis ventriculi dextri, which proceeds towards caudoventral on the ventral surface of ramus circumflexus dexter, is involved in the arterial vascularization of ventriculus dexter. Various numbers of thin lateral branches were separated from this branch in order to ensure the vascularization of the region during its course (Figure 2c,d and Figure 3c,d).

4. DISCUSSION

The study was similar to the literature findings [6,7,10,17,26]. As a result, it was discovered that arteria coronaria dextra et sinistra originating from the aorta ascendens provides arterial vascularization of the heart in Southern Karaman sheep. Unlike our findings, Aksoy et al. [27] found that a separate third coronary artery accompanied the arterial vascularization of the heart.

In contrast to research on buffalo, donkey, Malakan horse, and goat [9,14,28,29], arteria coronaria sinistra had a thicker layer than arteria coronaria dextra in our study. Similar to us in the most investigations in goat [30], Roe deer [19], and sheep [6,7], arteria coronaria sinistra was found to be thicker than arteria coronaria dextra. In the literature, it was observed that nine out of ten Awassi sheep [27], Hasak sheep [7], nine out of 14 Kıvırcık sheep [10], five out of ten Hemşin and Tuj sheep each [6], ramus proximalis atrii sinistri was separated from arteria coronaria sinistra. In this study, the literature findings of arteria coronaria sinistra [7,8,9,14,20,26,31,32] were similarly divided into ramus interventricularis paraconalis and ramus circumflexus sinister. Monfared et al. [18], on the other hand, found that, unlike our study findings, arteria coronaria sinistra was divided into three branches in 18.5% of cats.

Unlike our study findings, Doğruer and Özmen [10] reported that ramus interventricularis paraconalis terminated in 10 of the materials in Kıvırcık sheep, and Gürbüz and Aksoy [6] reported that it was terminated in facies auricularis in 6 of 10 Tuj and 7 of 10 Hemşin sheep. Similar to the literature [7,8], it was observed in the study that ramus interventricularis paraconalis ends by turning to facies atrialis before reaching incisura apicis cordis. Teke et al. [7] reported that, in accordance with our study findings, ramus collateralis sinister proximalis originates from the caudoventral of ramus interventricularis paraconalis and distributes to the upper 1/3 of the ventriculus sinister, while ramus collateralis sinister distalis originates from ramus interventricularis paraconalis in the caudoventral direction and it provides nutrition to the middle and distal 1/3 of the ventriculus sinister by taking it. Unlike the Hasak sheep [7], it was seen that a distal branch was separated from the ramus interventricularis paraconalis in the caudolateral direction to the ventriculus sinister after giving the ramus collateralis proximalis branch in the study. Despite the conclusions of the study, Aksoy ve Karadağ [17], Christensen and Campeti [31], and Gürbüz and Aksoy [6] revealed that in 5 Tuj and 4 Hemşin sheep, the ramus septalis was separated from the arteria coronaria sinistra. In contrast to the literature [7], the ramus coni arteriosi was identified as the second branch of the ramus interventricularis paraconalis, giving way to the facies atrialis after the ramus septalis.

In contrast to our findings, Gürbüz and Aksoy [6] found that ramus intermedius atrii sinistri was lacking in one of the materials and two of the Hemşin sheep in his study on Tuj sheep, and that ramus distalis atrii sinistri was responsible for vascularization of the region. Parallel to our study findings, in the literature [8,17], it was found that ramus proximalis ventriculi sinistri originates from the ventral aspect of the ramus circumflexus sinister. In addition, contrary to our findings, this artery sometimes originates from the angle between the ramus interventricularis paraconalis and the ramus circumflexus sinister in Kıvırcık sheep [10], in Tuj sheep [6] and Hemşin sheep [6]. According to Aksoy et al. [33], r. proximalis vetriculi sinistri was not found in two of five fox hearts. According to Doğruer and Özmen [10], the ramus marginis ventriculi sinistri is the second branch that separates from the ramus circumflexus sinister in the caudoventral direction, originates alone in 14 sheep, which is similar to our findings. Together with ramus distalis ventriculi sinistri in six sheep, which is contrary to our results. In addition to this, Gürbüz and Aksoy [6] stated that this artery started with ramus proximalis ventriculi sinistri in four Tuj and three Hemşin sheep, ramus distalis ventriculi sinistri in one Tuj and three Hemşin sheep, and in other materials the artery started from ramus circumflexus sinister as a

single root. Unlike the findings of the study on Hasak sheep [7], it was observed that ramus distalis ventriculi sinistri started in two branches. Similar to the study findings, it has been reported that ramus circumflexus sinister continues on its way as ramus interventricularis subsinuosus in sulcus interventricularis subsinuosus in cattle [8], sheep [10] and Hasak sheep after giving all these branches.

As reported in studies on alpaca [26], Hasak sheep [7] and Tuj and Hemşin breed sheep [6], arteria coronaria dextra originates from the aorta ascendens and proceeded between the truncus pulmonalis and auricula dextra, after reaching the sulcus coronarius, it continued on its way as ramus circumflexus dexter. Unlike our study findings, it has been reported in the literature [14,17] that arteria coronaria dextra is more dominant. Similar to the findings of the study [6,7,8], it has been reported in the literature that ramus proximalis atrii dextri, ramus coni arteriosi, ramus proximalis ventriculi dextri, ramus marginis ventricularis dextri orginated from arteria coronaria dextra. Unlike the findings in the literature [6-8], Özüdoğru [7] and our study revealed that ramus intermedius atrii dextri originated from ramus circumflexus dexter instead of arteria coronaria dextra. Contrary to the study findings, ramus coni arteriosi originates from the aorta ascendens in Kıvırcık sheep [10] and dog [34], and in Zavot cattle [35] and Malakan horse [28], it has been reported to originate as a single branch from arteria coronaria dextra. In 5 of the materials studied, ramus coni arterosi, ramus proximalis ventriculi dextri, and ramus proximalis ventriculi dextri came from a common root, similar to what was found in 3 Hasak sheep [7], 6 Hemşin sheep, and 4 Tuj sheep [6]. In Hasak breed sheep [7], Zavot breed cattle [35], and Malakan horses [28], it has been discovered that it originates in two branches from a single root separate from arteria coronaria dextra.

5. CONCLUSION

In the study, arterial vascularization of the heart was also provided by arteria coronaria dextra et sinistra and its branches in South Karaman sheep, but unlike arteria coronaria dextra et sinistra and its branches reported in the literature, in South Karaman sheep, it has been revealed that;

-Arteria coronaria sinistra is more dominant than arteria coronaria dextra,

-Ramus coni arteriosi is the second branch that separates from ramus interventricularis paraconalis,

-Ramus distalis ventriculi sinistri originates from ramus circumflexus sinister in two branches,

-Ramus intermedius atrii dextri originates from ramus circumflexus dexter.

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