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VENAE CORDIS AND MYOCARDIAL BRIDGES ON THE VENAE CORDIS IN TUJ AND HEMSHIN SHEEP

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Abstract. It was aimed to examine the venous drainage and myocardial bridges of the heart in Hemshin and Tuj sheep. Venae cordis of the sheep were examined by corrosion cast and latex injection techniques. The venous drainages of the hearts were observed to be supplied by *vena cordis magna, vena cordis media, venae cordis dextrae* and *venae cordis minimae*. The *vena marginis ventricularis sinistri* was opened into *vena cordis magna* in 50% of the Tuj and Hemshin sheep hearts and it was opened into the coronary sinus in the others. The coronary sinus were opened into *vena cava caudalis* in the 2 Hemshin sheep. The *vena distalis ventriculi sinistri* wasn't found in the Tuj and Hemshin sheep. The *venae cordis dextrae* were formed to *vena semicircumflexa dextrii* in 5 Hemshin sheep and Tuj sheep. The *venae cordis dextrae* was opened into righ atrium separately in the 5 Hemshin sheep. There were many anastomoses between cardiac veins in Tuj and Hemshin sheep. In 60% of Tuj and Hemshin sheep hearts were observed to have myocardial bridges on the *vena cordis media*, mostly on *incisura apicis cordis*. There weren't prominent differences with regard to coronary vessels between Tuj and Hemshin sheep.

Keywords: *Macroanatomy, myocardial bridges, sheep, venae cordis.*

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1. Introduction

The venous drainage of the hearts in domestic mammals is provided by *v. cordis magna, v. cordis media, vv. cordis dextrae* and *vv. cordis minimae* (Yadm & Gad, 1992; Tıpırdamaz *et al.*, 1999; Beşoluk & Tıpırdamaz, 2001; Nur *et al.*, 2002; Aksoy *et al.*, 2009; Yoldaş & Nur 2012; Yoldaş *et al.*, 2013). *V. cordis magna,* the largest of the veins that provide the venous drainage of the heart, originates by making anastomosis with *v. cordis media* from the apex of the heart (Hegazi, 1958; Kabak & Onuk, 2012) *V. cordis magna* courses as *v. interventricularis paraconalis* and v. *circumflexus sinister. V. interventricularis paraconalis* receives *v. collateralis sinister distalis et proximalis* and some veins from the ventriculus sinister, *v. coni arteriosi* and some veins from the ventriculus dexter and septum interventriculare in its course in sulcus interventricularis paraconalis (Aksoy *et al.*, 2009). *V. interventricularis paraconalis* proceeds as *v. circumflexus sinister* in sulcus coronarius and it receives *v. proximalis atrii sinistri, v. intermedius atrii sinistri* and *v. distalis atrii sinistri* from atrium sinistrum, *v. proximalis ventriculi sinistri, v. marginis ventricularis sinistri* and *v. distalis ventriculi sinistri* from ventriculus sinister. Then the *v. circumflexus sinister* opens into the sinus coronarius as *v. cordis magna* (Nickel *et al.*, 1981). *V. cordis media* takes some veins from the facies atrialis of the heart and septum interventriculare in its course in sulcus interventricularis subsinuosus and *v. cordis media* ends by opening into the sinus coronarius (Bhargava & Beaver, 1970). *Vv. cordis dextrae*, which collects the venous blood of the right half of the heart, takes *v. proximalis atrii dextri* from the atrium dextrum, *v. coni arteriosi*, *v. proximalis ventriculi dextri*, *v. marginis ventricularis dextri* and *v. distalis ventriculi dextri* from the ventriculus dexter. Then this veins open into atrium dextrum (Nickel *et al*., 1981). *Vv. cordis minimae* are mostly found in the atrium dextrum and fewer atrium sinistum and ventriculus dexter (Tıpırdamaz *et al*., 1999).

Myocardial bridges are formed by wrapping a subepicardial branches of coronary arteries and veins with myocardial muscles fibers (Kosinski *et al*., 2011). Myocardial bridges in humans have been associated some pathological conditions, such as, myocardial ischemia (Amitani *et al*., 2000), infarction (Diaz-Widmann *et al.*, 2003), interstitial fibrosis (Brodsky *et al.*, 2008) and malignant arrhythmia (Dermengiu *et al.*, 2010).

This study was performed with the aim of the investigation to macroanatomical structures of coronary veins and its myocardial bridges in the Hemshin and Tuj sheep widely grown in Artvin and Kars, respectively, in Turkey and determining whether there is any differences in the cardiac veins.

2. Materials and Methods

Animals: In the study, a total of 20 hearts were used, 10 being from Hemshin sheep and 10 from Tuj sheep among 6-10 month-old male sheep. The hearts of Hemshin sheep used in the study were obtained from the slaughterhouses in Kars, Artvin-Ardanuç, Tuj sheep hearts from Kars region in Turkey. The Animal Experiments Local Ethics committee's approval was not required as the study material was a slaughterhouse product.

Hearts: Coronary veins were examined by corrosion cast technique (Karadağ & Soygüder, 1989) in 5 Tuj and 5 Hemshin sheep and by latex injection technique (Aycan & Bilge, 1984) in the other 5 Tuj and 5 Hemshin sheep. After latex injection and corrosion cast, origin, origin diameter and drained areas of coronary veins were determined. The length of the myocardial bridges on coronary veins and the diameters of coronary veins were measured by digital caliper (0.00 BTS.UK). The results were photographed. Coronary veins were named according to Nomina Anatomica Veterinaria (2012).

Statistical analysis: Mean, standard deviation, and correlation values of the measurements were analysed in SPSS (20.0 version) programme. Independent Samples T test was applied to determine the differences of the measurements performed on the myocardial bridges and coronary veins between the Tuj and Hemshin sheep.

Abbrevations: **VCMag:** v. cordis magna, **VCM:** v. cordis media, **VCD:** vv. cordis dextrae, **VCMin:** vv. cordis minimae, **VMVS:** v. marginis ventricularis sinistri, **VIP:** v. interventricularis paraconalis, **VCS:** v. circumflexus sinister, **VIS:** v. interventricularis subsinuosus, **VCSD:** v. collateralis sinister distalis, **VCSP:** v. collateralis sinister proximalis, **VCA:** v. coni arteriosi, **VS:** vv. septales, **VPAS:** v. proximalis atrii sinistri, **VIAS:** vv. intermedius atrii sinistri, **VDAS:** v. distalis atrii sinistri, **VPVS:** v. proximalis ventriculi sinistri, **VA:** v. angularis, **VCDD:** v. collateralis dexter distalis, **VCDP:** v. collateralis dexter proximalis, **VPVD:** v. proximalis ventriculi dextri, **VMVD:** v. marginis ventricularis dextri, **VDVD:** v. distalis ventriculi dextri.

3. Results

The venous drainage of the hearts in Tuj and Hemshin sheep were determined by VCMag, VCM, VCD and VCMin. In generally this veins coursed subepicardially, but their branches were intramyocardially (Figure 1).

Sinus coronarius: Sinus coronarius placed from the basis of margo ventricularis sinister to sulcus interventricularis subsinuosus in the sulcus coronarius on the atrial face of the heart (Figure 2). Sinus coronarius was opened into the atrium dextrum in Tuj and Hemshin sheep but sinus coronarius was opened into v. cava caudalis in 2 Hemshin sheep (Figure 3). The diameter of sinus coronarius was 6.58±1.00 mm and 6.52±0.88 mm in Tuj and Hemshin sheep, respectively. Sinus coronarius was constituted of VCMag, VCM and v. azyos sinistra (Figure 4). Also there were unnamed branches drained to sinus coronarius from the atrial face of ventriculus sinister (Figure 2). However, VMVS was directly opened into sinus coronarius in 5 Tuj and 5 Hemshin sheep (Figure 2). In the other hearts, v. cordis magna and v. marginis ventricularis sinistri was formed a common root (Figure 4) then it was opened into sinus coronarius.

V. cordis magna: VCMag originated as VIP at the distal 1/3 of the sulcus interventricularis paraconalis (Figure 1). VCMag reached the sulcus coronarius through the ventral of the ramus (r.) circumflexus sinister in 7 Tuj and 4 Hemshin sheep (Figure 5) and through the dorsal of the r. circumflexus sinister in 3 Tuj and 6 Hemshin sheep (Figure 1). VCMag showed an enlargement in the hearts where the VCMag passed through the dorsal of r. circumflexus sinister (3 Tuj and 6 Hemshin sheep) where the vessels contacted to each other (Figure 1). In sulcus coronarius, VCMag turned to caudal as VCS and it was opened into sinus coronarius at the proximal of margo ventricularis sinister by taking veins from atrium sinistrum and ventriculus sinister. The diamater of VCMag was calculated as 2.97 ± 0.44 mm and 2.72 ± 0.84 mm at the near of sinus coronarius, in Tuj and Hemshin sheep, respectively.

V. interventricularis paraconalis: VIP originated as two branches at the level of distal 1/3 of sulcus interventricularis paraconalis and one of these branches was the anastomotic branch of VIS, and the other was VCSD (Figure 1). This vein progressed in sulcus interventricularis paraconalis and it received VCSP at the proximal 1/3 of this sulcus from the ventriculus sinister, VCA from conus arteriosus and VS from septum interventriculare. However, VIP received the unnamed veins that 2-5 branches in Tuj sheep, 3-7 branches in Hemshin sheep from ventriculus sinister, 3-5 branches in Tuj sheep, 3-6 branches in Hemshin sheep from ventriculus dexter, 11-16 branches from septum interventriculare in Tuj and Hemshin sheep. There was no statistical difference between the species in terms of the number of these veins ($P > 0.05$). Two of the proximal VS were stronger than distal VS. The proximal 1/3 part of the VIP was progressed under the subepicardial adipose tissue and the distal 2/3 part was only subepicardial.

V. circumflexus sinister: VCS was a continuation of VIP. VCS proceeded to caudal in the sulcus coronarius under subadiposal tissue and was opened into sinus coronarius at the proximal level of margo ventricularis sinister. In its course, VCS received VPAS, 1-3 branches VIAS, VDAS from the atrium sinistrum, VPVS from the ventriculus sinister. Also VCS received 3-4 branches unnamed veins from ventriculus sinister in 4 Tuj and 5 Hemshin sheep. VMVS was opened into v. circumflexus sinister in 5 Tuj and 5 Hemshin sheep (Figure 4). VMVS drained to margo ventricularis sinister of the heart (Figure 6). Also, there was VA at the angle between VIP and VCS in 7 Tuj and 7 Hemshin sheep. VA drained to proximal 1/3 level of ventriculus sinister on the auricular face of the heart.

V. distalis ventriculi sinistri was not found in Tuj and Hemshin sheep. Drainage of the area where v. distalis ventriculi sinistri should resist was provided by the unnamed veins opening into VMVS.

V. cordis media: VCM was formed by the merger of 2 branches just above apex cordis. VCM run in the sulcus interventricularis subsinuosus as VIS and was opened into sinus coronarius (Figure 2). But VCM was opened into v. cava caudalis in 2 Hemshin sheep (Figure 3). In its courses it was subepicardially in 8 Tuj and 4 Hemshin sheep and the distal 1/2 of the VCM was intramyocardially in 2 Tuj and 6 Hemshin sheep. It received VCDD in 3 Tuj and 3 Hemshin sheep, VCDP in 7 Tuj and 7 Hemshin sheep from the from atrial surface of the ventriculus dexter (Figure 2). In addition to these branches, VCM received 6-8 branches from ventriculus dexter, 5-10 branches from ventriculus sinister and 6-11 branches from septum interventriculare. In general, the number of branches that VCM received from the ventriculus sinister was more than the number of branches taken from the ventriculus dexter, and it received the most branches from the septum interventriculare.

The venous drainage of the apex cordis was provided by the branches of VMVS and VIS. In 5 Tuj sheep the venous drainage of the apex cordis was supplied by only the branches of VMVS. Also in 5 Tuj sheep, a dense vein network was found in apex cordis (Figure 7).

The diamater of VCM was calculated as 2.48±0.34 mm, 2.34±0.27 mm mm, at the level of its proximal, in Tuj and Hemshin sheep, respectively. There were no statistically differences between the diamater of VCM in Tuj and Hemshin sheep ($P > 0.05$).

Vv. cordis dextrae: VCD provided venous drainage of the right half of the heart (Figure 8, 9). VCD originated from the begining level of the arteria (a.) coronaria dextra and it coursed cranially under the atrium dextrum in the sulcus coronarius. VCD received that VCA from conus arteriosus, VPVD and VMVD from ventriculus dexter, VPAD from atirum dextrum (Figure 10). VDVD was directly opened into atrium dextrum. VCD formed to v. semicircumflexa dextrii in all of the Tuj sheep and 5 Hemshin sheep (Figure 9). There was no v. semicircumflexa dextrii in 5 Hemshin sheep, in these hearts, the veins seperately drained to ventriculus dexter and opened directly into atrium dextrum (Figure 10).

Vv. cordis minimae: VCMin was found on the wall of atrium dextrum and ventriculus dexter.

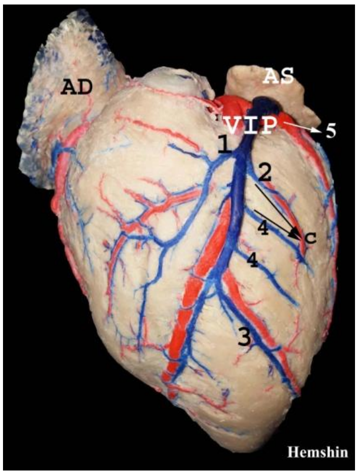

Figure 1. The view of the auricular surface of the Hemshin sheep's heart
1. VCA, **2.** VCPS, **3.** VCDS, **4.** The unnamed veins that drained to VIP from ventriculus sinister wall, **5.** R. circumflexus sinister

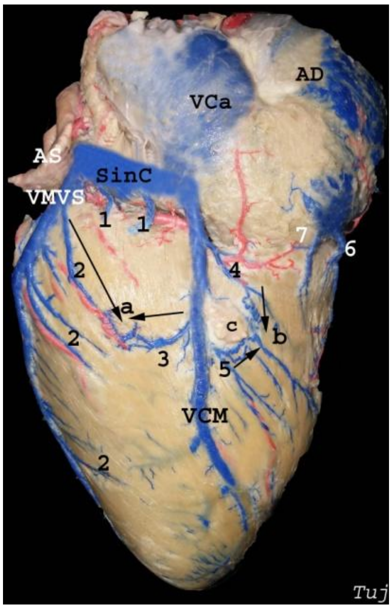

Figure 2. The view of atrial surface of the Tuj sheep's heart.
1. The unnamed veins that were drained to SinC from sulcus coronarius, **2.** The veins that were drained to VMVS from venticulus sinister, **3.** The vein that opened into VCM from ventriculus sinister, **4.** VCDD, **5.** VCDP, **6.** VDVD, **7.** Vein that opened into atrium dextum from ventriculus dexter, **a.** The anastomosis between the branches of VMVS and VCM, **b.** Anastomosis between VCDD and VCDP

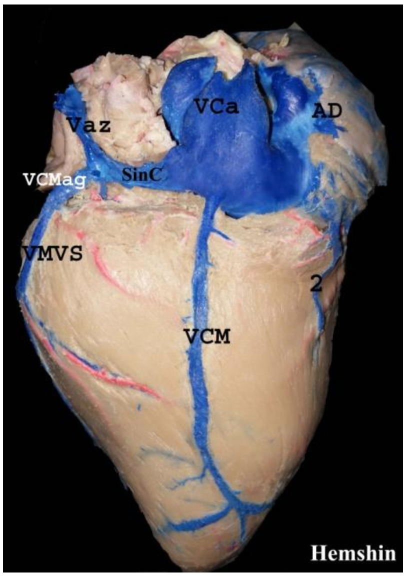

Figure 3. The Sinus coronarius was drained to vena cava caudalis in 2 of the Hemshin sheep's hearts.
2. VDVD

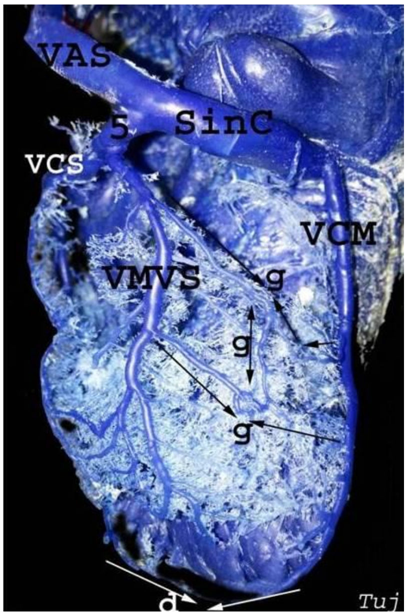

Figure 4. The venous drainage of the heart in Tuj sheep (corrosion cast)
5. The common root of VMVS and VCS, **d.** The anastomosis between VIP and VCM (VIS), **g.** The anastomosis between the branches of VMVS and the branches of VCM.

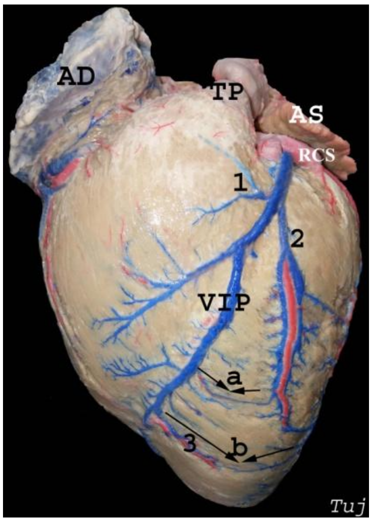

Figure 5. The view of the auricular surface of the Tuj sheep's heart
1. VCA, **2.** VCSP, **3.**VCSD, **RCS.** R. circumflexus sinister, **a.** Anastomosis between the branches of VIP and VCSP, **b.** Anastomosis between the branches of VCSP and VCSD

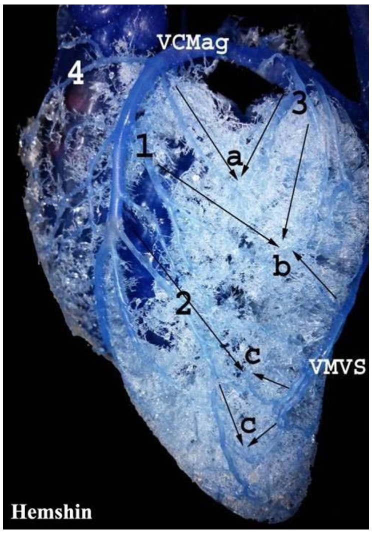

Figure 6. The auricular surface of the heart in Hemshin sheep (corrosion cast).
1. VCSP, **2.** VCSD, **3.** VPVS, **4.** VCA, **a.** Anastomosis between the branches of VCMag and VPVS, **b.** Anastomosis between the branches of VMVS, VCSP and VPVS, **c.** Anastomosis between the branches of VMVS and VCSD

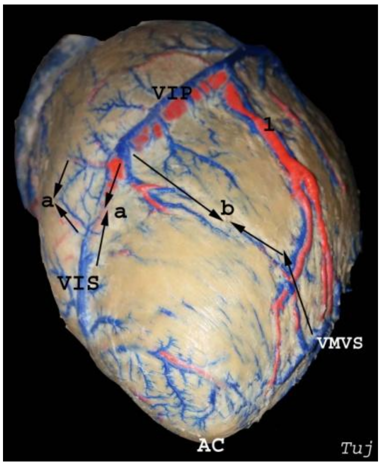

Figure 7. The view of apex cordis in Tuj sheep (The dense venous network in 5 of the Tuj sheep's heart). **AC.** Apex cordis, **a.** Anastomosis between VIP and VIS, **b** Anastomosis between the distal branches of VIP and VMVS, **1.** VCSD

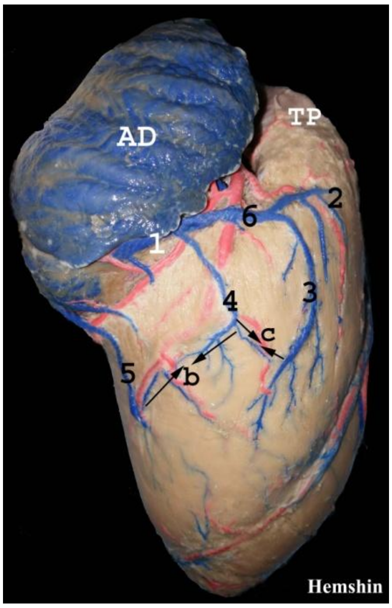

Figure 8. V. cordis dextra in Hemshin sheep.
1. V. semicircumflexa dextrii, **2.** VCA, **3.** VPVD, **4.** VMVD, **5.** VDVD, **6.** The radix VCA and VPVD**, b.** Anastomosis between VDVD and VMVD, **c.** Anastomosis between VMVD and VPVD

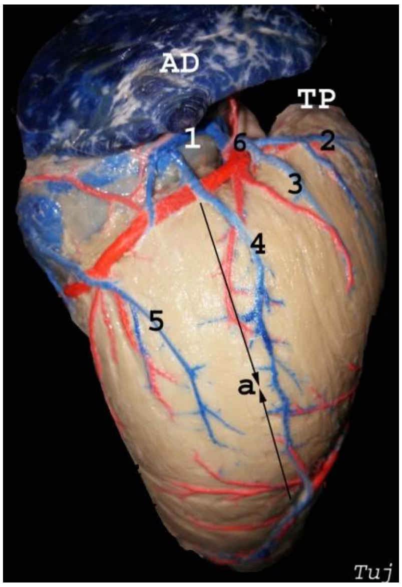

Figure 9. V. cordis dextra in Tuj sheep.
1. V. semicircumflexa dextrii, **2.** VCA, **3.** VPVD, **4.** VMVD, **5.** VDVD, **6.** The radix VCA and VPVD**, a.** Anastomosis between VMVS and VIP

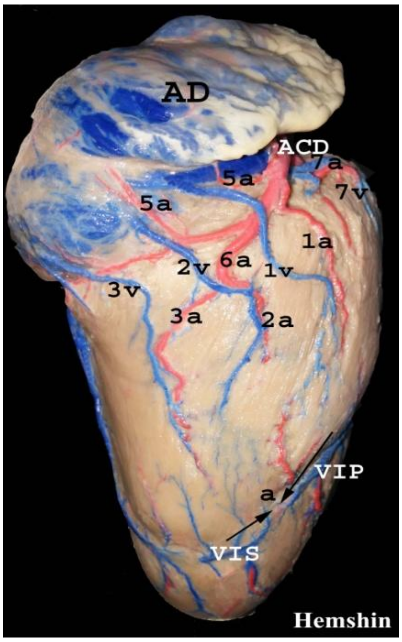

Figure 10. V. cordis dextra in Hemshin sheep (The veins were drained to atrium dextrum seperately in 5 Hemshin sheep).
1v. VPVD, **2v.** VMVD, **3v.** VDVD, **7v.** VCA, **a.** Anastomosis between VIP and VIS

Anastomoses: A great number of anastomoses were found between the venae cordis. The anastomoses that were determined between the veins were shown in the Table 1. (Figure 1, 2, 4, 5, 6, 7, 8, 9, 10).

Table 1. The anastomoses of the venae cordis in Tuj and Hemshin sheep

The number of the hearts to which anastomosis was determined	**Anastomoses between the veins**
In 1 Tuj and 1 Hemshin sheep	VPVS and the branches of unnamed vein that run between the VCSD and VCSP
In 5 Tuj and 6 Hemshin sheep	VCSD and VIS
In 9 Tuj and 9 Hemshin sheep	VCSD and the branches of VMVS
In 2 Tuj and 6 Hemshin sheep	The branches of VCSD and the branches of VCSP
In 6 Tuj and 6 Hemshin sheep	The branches of VCSD and some branches of VIP from ventriculus sinister
In 1 Tuj and 2 Hemshin sheep	VCSP and the branches of VIS from ventriculus sinister anastomosed at the distal 1/3 level of margo ventricularis sinister
In 2 Tuj and 3 Hemshin sheep	VCSP and VPVS
In 3 Tuj and 4 Hemshin sheep	The branches of VCSP and the branches of VIP from ventriculus sinister
In 1 Hemshin sheep	VCSP and VA
In 7 Tuj and 8 Hemshin sheep	VCSP and the branches of VMVS
1 Tuj and 2 Hemshin sheep	v. coni arteriosi dextri and v. coni arteriosi sinistri
1 Tuj and 4 Hemshin sheep	V. coni arteriosi dextri and VPVD
2 Tuj and 3 Hemshin sheep	V. angularis and VPVS
In 3 Hemshin sheep	VA and the proximal branches of VIP from ventriculus sinister
In 1 Hemshin sheep	VPVS and the branches of VIS from ventriculus sinister anastomosed at the distal 1/3 of margo venticularis sinister
In 2 Tuj and 7 Hemshin sheep	VPVS and the branches of VMVS
In 1 Hemshin sheep	VPVS and the proximal branches of VIP from ventriculus sinister
In 3 Tuj and 7 Hemshin sheep	The branches of VMVS and the branches of VIS-VIP from ventriculus sinister
In all of the Tuj and Hemshin sheep	The branches of VMVS and the branches of VCM
In all of the Tuj and Hemshin sheep	VIP and VCM at the level of incisura apicis cordis

Myocardial bridges: In general, the origin of the veins advanced intramyocardially then their course were subepicardially. But some vein, espacially at the distal of the hearts, were found under the myocardial bridges (Figures 11, 12). These myocardial bridges and their lenght were shown in Table 2 in Hemshin sheep, Table 3 in Tuj sheep.

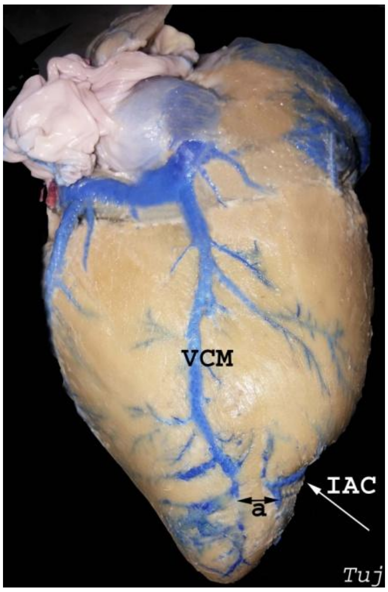

Figure 11. The myocardial bridge on the VCM at the incisura apicis cordis in Tuj sheep.
a. Myocardial bridge on the VCM, **IAC.** Incisura apicis cordis

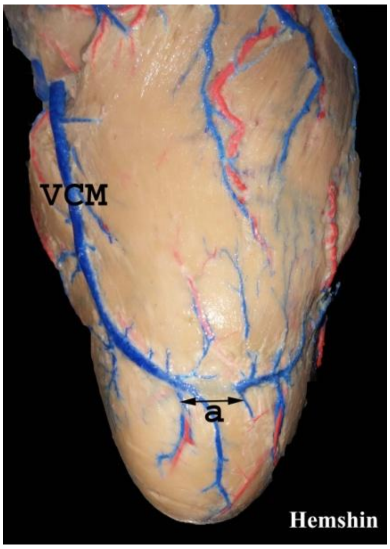

Figure 12. The myocardial bridge on the VCM at the incisura apicis cordis in Hemshin sheep.
a. Myocardial bridge on the VCM

Table 2. The values of length of the myocardial bridges in Hemshin sheep

The number of the hearts that found myocardial bridges	The myocardial bridges on the VCM at the level of incisura apicis cordis	The myocardial bridges on the VCM at the level of sulcus interventricularis subsinuosus
In 4 Hemshin sheep	0.5 cm	-
In 1 Hemshin sheep	-	2.0 cm
In 1 Hemshin sheep	0.6 cm	-

Table 3. The values of lenght of the myocardial bridges in Tuj sheep

The number of the hearts that found myocardial bridges	The myocardial bridges on the VCM at the level of incisura apicis cordis (Myocardial bridge-1)	The myocardial bridges on the VCM at the level of incisura apicis cordis (Myocardial bridge -2)	The myocardial bridges on the VDVD
In 1 Tuj sheep	0.2 cm	0.5 cm	-
In 2 Tuj sheep	0.5 cm	-	-
In 1 Tuj sheep	1.3 cm	-	-
In 1 Tuj sheep	2.3 cm	-	-
In 1 Tuj sheep	2.5 cm	-	0.3 cm

4. Discussion and Conclusion

The venous drainage of the heart in Tuj and Hemshin sheep was provided by v. cordis magna, v. cordis media, vv. cordis dextrae and vv. cordis minimae in accordance with literature (Nickel *et al*., 1981; Barszcz 2020). V. marginis ventricularis sinistri was directly opened into sinus coronarius in 10% of the Tuj sheep (Aksoy *et al*., 2009), 23.5% of Akkaraman sheep (Aydınlık *et al*., 2008), 88.8% of Roe deer (Kabak & Onuk, 2012) and 29.5% of dog (Esperança Pina *et al*., 1981). In the other hearts, v. marginis ventricularis sinistri was opened into v. cordis magna (Aksoy *et al.,* 2009; Aydınlık *et al*., 2008; Kabak & Onuk, 2012; Esperança Pina *et al.*, 1981). However, Hegazi (1958) reported that the v. marginis ventricularis sinistri was opened into sinus coronarius in sheep and, it was opened into v. cordis magna in goat. In 50% of Tuj and 50% of Hemshin sheep v. marginis ventricularis sinistri was directly opened into sinus coronarius and in the other hearts it was opened into v. cordis magna as stated in the literature (Aksoy *et al.*, 2009, Aydınlık *et al.,* 2008, Kabak & Onuk 2012; Esperança Pina *et al*., 1981). In these hearts v. cordis magna and v. marginis ventricularis sinistri was formed a common root, then it was opened into the sinus coronarius. The common root that was formed by the v. marginis ventricularis sinistri and v. cordis magna was not mentioned in the literature (Aksoy *et al*., 2009; Aydınlık *et al.*, 2008; Kabak & Onuk 2012).

The sinus coronarius was found in cattle, sheep, goat (Nickel *et al*., 1981), human (Pakalska, 1974), ostrich (Yoldaş, 2007), chicken, quail (Mark *et al.,* 1997) and porcupine (Atalar *et al*., 2004) like in Tuj and Hemshin sheep. The sinus coronarius was directly opened into atrium dextrum in Tuj and 8 Hemshin sheep as shown in literature (Nickel et al., 1981). But the sinus coronarius was opened into v. cava caudalis in 2 Hemshin sheep. In the literature, no findings related to the opening of sinus coronarius to cava caudalis have been encountered in sheep.

It has been reported that the diameter of sinus coronarius was 2.5 cm in sheep (Hegazi, 1958), 2.0-2.5 cm in goat (Yadm & Gad, 1992), 3.5-5.0 cm in cattle, 2.0-3.0 cm in pig, 2.0-3.0 cm in dog (Nickel *et al*., 1981), in 4-10 mm in dog (Esperença Pina *et al.*, 1981). But the diamater of the sinus coronarius was 6.58 mm and 6.52 mm in Tuj and Hemshin sheep respectively, as in accordance with dog (Esperença Pina *et al*., 1981).

V. cordis magna reached from the sulcus interventricularis paraconalis to sulcus coronarius through the ventral of the r. circumflexus sinister in in sheep and goat

(Tıpırdamaz *et al.*, 1999) like in 7 Tuj and 4 Hemshin sheep. But it reached through the dorsal of the r. circumflexus sinister in 3 Tuj and 6 Hemshin sheep.

Yoldaş et al. (2013) found two strongest veins in storks and these veins were equivalent to v. marginis ventricularis sinistri and v. marginis ventricularis dextri in mammals. Aksoy et al. (2001) reported that v. marginis ventricularis sinistri was the strongest of the ventricular veins in cat. In Tuj and Hemshin sheep, v. marginis ventricularis sinistri was the strongest of ventricular veins, too. The course of v. marginis ventricularis sinistri was subepicardial as indicated in Tuj sheep (Aksoy *et al.*, 2009) and roe deer (Kabak & Onuk, 2012).

V. angularis was existence in Tuj sheep (Aksoy *et al*., 2009), roe deer (Kabak & Onuk, 2012), donkey (Yadm & Gad, 1992) and some rabbits (Kresakova *et al*., 2014) in accordance with 7 Tuj and 7 Hemshin sheep.

In literature (Aksoy *et al.* 2009, Kabak & Onuk 2010) it was stated that, v. collateralis sinister proximalis was thicher than v. collateralis sinister distalis. In the study, v. collateralis sinister proximalis in 3 Tuj and 3 Hemshin sheep, v. collateralis sinister distalis in 4 Tuj and 4 Hemshin sheep was found to be stronger and in others there was no superiority between these vessels.

Aksoy et al. (2009) stated that, v. distalis ventriculi sinistri was opened into sinus coronarius in 5 hearts, into v. cordis magna in 2 hearts and the vein was not found in 3 hearts in Tuj sheep. Also v. distalis ventriculi sinistri was opened into sinus coronarius in roe deer (Kabak & Onuk, 2012) and Akkaraman sheep (Beşoluk & Tıpırdamaz, 2001), and it was opened into v. circumflexus sinister in Angora goat (Beşoluk & Tıpırdamaz, 2001). In this study in all of the Tuj and Hemshin sheep v. distalis ventriculi sinistri was not found as reported in 3 Tuj sheep (Aksoy *et al*., 2009).

As indicated in the reference (Aksoy *et al.,* 2009; Kabak & Onuk, 2012), in Tuj and Hemshin sheep, the branches of v. interventricularis paraconalis and v. interventricularis subsinuosus coursed intramyocardially. The distal half of the v. interventricularis subsinuosus run intramyocardially in sheep (Beşoluk & Tıpırdamaz, 2001; Aksoy *et al*., 2009) and roe deer (Kabak & Onuk, 2012), but in the study, it coursed subepicardially in 8 Tuj and 4 Hemshin sheep, in others the distal half of this vein was intramyocardially like in sheep and roe deer.

The venous drainage of septum interventriculare was provided by v. cordis media and v. cordis magna in sheep (Aksoy *et al*., 2009) like in Tuj and Hemshin sheep. There were found 8-10 branches of vv. septales in donkey (Yadm & Gad, 1992). The number of branches that v. cordis media received from septum interventriculare were 6-11, and the number of branches that v. interventricularis paraconalis received from septum interventriculare were 11-16 in Tuj and Hemshin sheep. It has been seen that the findings in Tuj and Hemshin sheep were in close proximity with the findings of Yadm & Gad (1992).

V. cordis media ended in sinus coronarius as it was reported in the literature (Tıpırdamaz et al., 1999). However, it was expressed that v. cordis media was opened into atrium dextrum in sheep (Hegazi, 1958), and it sometimes directly was opened into atrium dextrum in cattle (Nickel *et al.*, 1981) and bison (Barszcz *et al.*, 2020).

Vv. cordis dextrae drained to atrium dextrum in goat (Yadm & Gad, 1992), in ruminantia (Tıpırdamaz *et al.*, 1999), in sheep (Beşoluk & Tıpırdamaz, 2001; Aksoy *et al.*, 2009) and 50% of the cat hearts (Aksoy *et al.*, 2003) as similar to the findings in Tuj and Hemshin sheep. V. semicircumflexa dextrii was existence in ruminantia (Nickel *et al.*, 1981), in Tuj sheep (Aksoy *et al*., 2009), in roe deer (Kabak & Onuk, 2012) like in

10 Tuj and 5 Hemshin sheep. However, v. semicircumflexa dextrii was not found in stork (Yoldaş *et al*., 2013) like in 5 Hemshin sheep.

In accordance with the literature (Hemmoda & Amin, 1989; Barszcz *et al*., 2020) in Tuj and Hemshin sheep, there were anastomosis was observed between the first branches of v. cordis magna and v. cordis media. In addition, v. collateralis sinister proximalis and v. collateralis sinister distalis were anastomosed to v. marginis ventricularis sinistri in some Tuj and Hemshin sheep in line with the findings of Aksoy et al. (2009) and Kabak & Onuk (2012). In conclusion in accordance with the findings of sheep (Aydınlık *et al*., 2008; Aksoy *et al*., 2009), goat (Tıpırdamaz *et al.*, 1999), cat (Aksoy *et al.,* 2003) and roe deer (Kabak & Onuk, 2012), it was determined that there were too much anastomosis between the venae cordis.

Tıpırdamaz et al. (1999) stated that there was a dense venous network in apex cordis in goats like in 5 Tuj sheep. However, the same literature (Tıpırdamaz *et al*., 1999) stated that there was no venous network in apex cordis in sheep, as it was determined in 5 Tuj sheep and all of the Hemshin sheep.

Lüdinghausen (1987) was reported that in 2% of 350 hearts, v. cordis magna was covered with a myocardial bridge that was calculated in 2-11 mm, and during the ventricular systole, the vein may have been exposed to more or less pressure by this myocardial bridge. In the study, while there was no myocardial bridge on v. cordis magna on the contrary to the finding of Lüdinghausen (1987), the myocardial bridges were found on v. cordis media. The lengths of myocardial bridges on v. cordis media were determined as 1.21 cm and 0.76 cm in Tuj and Hemshin sheep, respectively. The difference between the length of the myocardial bridge between Tuj and Hemshin sheep was not statistically significant ($P > 0.05$). The studies about myocardial bridges on the coronary veins in animals were few. So there was not enough literature to compare with the results obtained in the study. Also, when studies were conducted on myocardial bridges, it was concluded that in generally, the myocardial bridges on the coronary veins are mostly located at the distal 1/3 level of the heart, while the myocardial bridges on the coronary arteries (Gürbüz & Aksoy, 2019) are located at the proximal 2/3 level of the hearts in animals.

In conclusion, this study, in which the macroanatomical properties of coronary veins and myocardial bridges on the coronary veins were determined in Tuj and Hemshin sheep, is thought to contribute to anatomical studies in order to eliminate the literature deficiency in terms of species. At the same time, it can contribute to the formation of sheep heart as a model for educational purposes. Thus, it was concluded that it may help to better identify the coronary veins.

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References

Aksoy, G., Özmen, E., Kürtül, İ., Özcan, S. & Karadağ H. (2009). The venous drainage of the heart in the Tuj sheep. *Kafkas Universitesi Veteriner Fakultesi Dergisi, 15*(2), 279-286.

Amitani, K., Yamaguchi, T., Takahashi, N., Uchida, T., Kushikata, Y., Munakata, K., Masuda, S. & Orii, T. (2000). Two cases of myocardial bridge associated with myocardial ischemia. *Journal of Nippon Medical School, 67*(3), 206-209.

Angelini, P., Trivellato, M., Donis, J. & Leachman, R.D. (1983). Myocardial bridges: a review. *Progress in Cardiovascular Diseases,* 26, 75-88.

Aydınlık, E., Aycan, K. & Ekinci, N. (2008). Akkaraman koyununda koroner venlerin anatomisi. *Erciyes Universitesi Sağlık Bilimleri Dergisi, 17*(1), 40-45.

Barszcz, K., Polguj, M., Gozdziewska-Harlajczuk, K., Kleckowska-Nawrot, J., Olbrych, K., Haldaj, R. & Kupczynska, M. (2020). Gross anatomy of the coronary veins of the European Bison (Bison bonasus). *BMC Veterinary Research,* 16, 38. doi: 10.1186/s12917-020-2259-0

Beşoluk, K. & Tıpırdamaz, S. (2001). Comparative macroanatomic investigations of the venous drainage of the heart in Akkaraman sheep and Angora goats. *Anatomy Histology Embryology,* 30, 249-252.

Bhargava, I. & Beaver, C. (1970). Observations on the arterial supply and venous drainage of the bovine heart. Anatomischer Anzeiger, 126, 343-351.

Brodsky, S.V., Roh, L., Ashar, K., Braun, A. & Ramaswamy, G. (2008). Myocardial bridging of coronary arteries: a risk factor for myocardial fibrosis?. *International Journal of Cardiology, 124*(3), 391-2.

Diaz-Widmann, J., Cox, S.L. & Roogsritong, C. (2003). Unappreciable myocardial bridge causing anterior myocardial infarction and postinfarction angia. *Southern Medical Journal, 96*(4), 400-402.

Dermengiu, D., Vovolis, I., Hostiuc, S., Curca, G.C., Rusu, M.C. & Luca, M. (2010). Morphological features in myocardial bridging. *Romanian Journal of Legal Medicine,* 18, 163-170.

Esperança-Pina, J.A., Correia, M., Goyri, O.N. & Bensabat-Rendas, A. (1981). Morphology of the veins draining the coronary sinus of the dog. *Acta Anatomica,* 109, 122-128.

Gürbüz, İ. & Aksoy, G. (2019). Macroanatomical investigation of arteria coronaria and myocardial bridges in Tuj and Hemshin sheep. *Indian Journal of Animal Research,* Inpress. doi: 10.18805/ijar.B-1142.

Hegazi, H. (1958). Die blutgefössversorgung des herzens von rind, schaf und ziege. Inaugural Dissertation, Giessen, 1958.

Hemmoda, A.K. & Amin, M.E. (1989). Venous drainage of the heart of buffalo. *Zagazig Veterinary Journal, 17*(1), 91-105.

International Committee on Veterinary Gross Anatomical Nomenclature (2012). *Nomina Anatomica Veterinaria* (N.A.V.), 5th ed., World Association of Veterinary Anatomists, Hannover, Columbia, Gent, Sapporo.

Kabak, M. & Onuk, B. (2012). Macroanatomic investigation on the venous drainage of the heart in Roe Deer (Capreolus capreolus). *Kafkas Universitesi Veteriner Fakultesi Dergisi, 18*(6), 957-963.

Kosinski, A., Grzybiak, M., Piwko, G. & Kozlowski, D. (2011). Myocardial bridges in domestic pig- morphological aspects. *Polish Journal of Veterinary Sciences, 14*(3), 411-416.

Lüdinghausen, M.V. (1987). Clinical anatomy of cardiac veins, Vv cardiaca. *Surgical and Radiologic Anatomy,* 9, 159-168.

Nickel, R.A., Schummer, A. & Seiferle, E. (1981). *The anatomy of the domestic animals.* Volume 3, the circulatory system: Verlag Paul Parey, Berlin Hamburg.

Nur, İ.H., Yoldaş, A. & Arı, H.H. (2002). Van Kedilerinin Kalp Venleri Üzerinde Makroanatomik Bir Çalışma. II: Ulusal Veteriner Anatomi Kongresi, Side, Antalya.

Tıpırdamaz, S., Yalçın, H., Beşoluk, K. & Eken, E. (1999). Ruminantlarda toplardamarlar: Selçuk Üniversitesi Basımevi, Konya.

Yadm, Z.A. & Gad, M.R. (1992). Origin, course and distribution of the venae cordis in the rabbit and goat (comparative study). *Veterinary Medical Journal,* 40, 1-8.

Yamaguchi, M., Tangkawattana, P. & Hamlin, R.L. (1996). Myocardial bridging as a factor in heart disorders: critical review and hypothesis. *Acta Anatomica*, 157, 248-260.

Yoldaş, A. & Nur, İ.H. (2012). The distribution of the cardiac veins in the New Zealand White rabbits (Oryctolagus cuniculus). *Iranian Journal of Veterinary Research, Shiraz Uni, 13*(3), 40.

Yoldaş, A., Özmen, E. & Aksoy, G. (2013). The anatomy of the cardiac veins in storks (Ciconia ciconia). *Kafkas Universitesi Veteriner Fakultesi Dergisi, 19*(4), 687-692.