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A Macroanatomic and Subgross Study on Coronary Arteries of Chukar Partridges

Ayhan FİDAN[1] Gamze ÇAKMAK[2]

[1] *Van Yuzuncu Yil University, Health Science Institute, Department of Anatomy, Van, Turkey*
[2] *Van Yuzuncu Yil University, Faculty of Veterinary Medicine, Department of Anatomy, Van, Turkey*

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ABSTRACT This study was conducted to make a macroanatomic examination on properties of coronary arteries in partridges. It was decided to conduct this study due to a limited number of studies on the poultry heart. In the study, 10 chukar partridges (*Alectoris chukar*) were used. Corrosion casting technique and latex injection were applied on the hearts. It was remarkable that left coronary artery of the partridges was thicker than their right coronary artery. It was seen that the branches of left coronary artery were profound and superficial branches. Interventricular paraconal branch, conal branches, ventricular branches, atrial branches and circumflex originated from superficial branch. Septal branches and ventricular branches were originated from profound branch. It was determined that the branches of right coronary artery were superficial and profound branches. It was determined that interventricular subsinuosal branch and circumflex branch were originated from superficial branch. Circumflex branch had atrial and ventricular branches. Septal and ventricular branches were originated from profound branch.

Keywords: *Coronary arteries, Corrosion Cast, Heart, Latex, Partridge*

ÖZ

Kınalı Kekliğin Koroner Arterleri Üzerine Makroanatomik ve Subgros Bir Çalışma

Bu çalışma, keklikte koroner arterlerin özelliklerini makroanatomik olarak incelemek için yapıldı. Kanatlı kalbi üzerine yapılan çalışmaların az olması sebebiyle bu çalışmanın yapılmasına karar verildi. Yapılan çalışmada 10 adet kınalı keklik (*Alectoris chukar*) kullanıldı. Kalplere korozyon kast tekniği ve latex enjeksiyon metodu uygulandı. Keklikte a. coronaria sinistra'nın a. coronaria dextra'dan kalın olduğu dikkat çekti. A. coronaria sinistra'nın dallarının r. profoundus ve r. superficialis olduğu görüldü. R. superficialis'ten r. interventricularis paraconalis, rr. conales, rr. ventriculares, rr. atriales ve circumflexus'un çıktığı tespit edildi. R. profoundus'tan rr. septales ve rr. ventriculares'in orijin aldığı saptandı. R. superficialis'ten r. interventricularis subsinuosus ve r. circumflexus'un çıktığı belirlendi. R. circumflexus'un da rr. atriales ve rr. ventriculares'i verdiği tespit edildi. R. profoundus'tan rr. septales ve rr. ventriculares'in çıktığı tespit edildi. A. coronaria dextra'nın dallarının r. superficialis ve r. profoundus olduğu saptandı. R. superficialis'ten r. interventricularis subsinuosus ve r. circumflexus'un çıktığı rapor edildi. R. circumflexus'un da rr. atriales ve rr. ventriculares'i verdiği ifade edildi. R. profoundus'tan rr. septales ve rr. ventriculares'in çıktığı tespit edildi.

Anahtar Kelimeler: *Koroner arterler, Korozyon Kast, Kalp, Lateks, Keklik*

INTRODUCTION

Heart is supplied by two coronary vessels originated from the aorta in birds (Lindsay and Smith 1965; Nickel et al. 1977; Dursun 2002) and mammals (Dursun 1994). Coronary arteries are originated from bulbus aorta in the cranial of the location where the aortic valve cusps are attached to the wall in birds (Hodges 1974, Baumel 1975). Every coronary artery is divided into branches as superficial branch and profound branch around their origins (Baumel 1975). In mammals (Dursun 1994) and birds (Baumel 1975), right coronary artery arise from right aortic sinus at the semilunar valve level and continue in a convoluted way in the fat mass within coronary groove located between right ventricle and right auricle. In birds, it is seen that right coronary artery is divided into two branches as superficial branch located on the surface and deeply located profound branch (Baumel 1975; Nickel et al. 1977). In birds (Baumel 1975) and mammals (Dursun 1994), superficial branch of right coronary artery is divided

Corresponding author: Gamze ÇAKMAK
Van Yuzuncu Yil Univ., Veteriner Fak, Anatomi AD, Kampus, Van, Turkey *e-mail: vetgamze@hotmail.com*

in two branches in its course in coronary groove. In general, the smaller branch on the left side supplies blood to conus arteriosus that is attached to a part of the wall of right ventricle. The right branch, the larger one, is the continuation of superficial branch. This branch courses in coronary groove around the surface of the heart and it leads to an anastomosis in the dorsal area of the heart with the ends of left circumflex artery. In birds, profound branch of right coronary artery is stronger than superficial branch. Profound branch supplies blood to a part of the ventral wall of right ventricle, right atrioventricular cuspis and the dorsal walls of both atriums, to interventricular septum, the dorsal part of right ventricle, and the apex of the heart (Lindsay and Smith 1965; Baumel 1975). In mammals (Dursun 1994; Aksoy et al. 2003) and birds (Dursun 2002), left coronary artery is originated from the sinus aorta at the level of left semilunar valve and passes between pulmonary trunk and the left auricle in order to reach and tend towards coronary groove. In poultry, left coronary artery is divided in superficial and profound branches after it reaches towards basis of heart from between left atrium and pulmonary trunk. Superficial branch of left coronary artery continues in the left dorsal arch on the external side of coronary groove. It gives small atrial and large ventricular branches (Baumel 1975). It enters interventricular septum in the area where the thicker profound branch gives the secondary branches on the wall of left ventricle. These branches also anastomose in atrial faces with the secondary branches, like superficial branch (Nickel et al. 1977).

MATERIALS and METHODS

In the study, 10 chukar partridges (*Alectoris chukar*) were used regardless of the sex. The partridges reared by the Van Yuzuncu Yil University Directorate of Wildlife Conservation and Rehabilitation Center for release to nature were supplied as live material.

The partridges were anesthetized by making an intramuscular injection of 0.5 ml rompun and 0.5 ml ketamine (6 mg/kg). Thus, the chukar partridges were taken under sedative effect for 2 hours (Allen and Oosterhuis 1986; Ali et al. 1987; Gonder and Barnes 1989). In order to prevent coagulation after premedication, 5 mg/kg heparin 1-1.5 ml and also 0.9% normal saline were injected from axillary vein which is a branch of subclavian vein (Baumel et al. 1993). In order to determine the location of the heart and the connections of the heart, a 8-10 cm long incision was done over the linea alba and the thoracoabdominal area was opened. From an external perspective, the thoracic cavity and the heart were made visible. After cranial cava vena, caudal cava vena and aorta were ligatured, these veins were cut under the ligatures and the heart was resected from the thoracic cavity together with ascending aorta, cranial cava vena, caudal cava vena, and trachea. In order to prevent the extravasation of stained latex, left and right brachiocephalic arteries were ligatured without damaging the vein wall (Aksoy 2000; Cakmak 2007).

For the latex injection, 6 ml latex and 2 ml colorant (deka permanent 20/20) red fabric dye were mixed with a glass stirrer in 20 ml injectors and it was provided to diffuse the colorant in latex. In addition, the injector was agitated. A catheter was inserted in ascending aorta and this mixture was administered to ascending aorta via the catheter. When it was observed that the heart and coronary arteries were filled, the injection procedure was terminated. Ascending aorta was ligatured. The hearts to which latex injection was applied were kept in a 10% formaldehyde solution in order to provide a good fixation.

For the corrosion casting model, 10 ml liquid monomethylmetacrylate and 5 gr powdered polymethylmetacrylate and 3 ml SNOWMAN red glass board marker paint were mixed and takilon was obtained (Hassa 1977). 6-8 ml of this mixture prepared by the method applied for latex hearts was administered via the catheter inserted to ascending aorta. Hearts with takilon were kept at room temperature for 24 hours and then in 10% KOH for 24 hours for polymerisation. Thus, the maceration of soft tissues was provided (Hassa 1977; Karadag and Soyguder 1989; Noestelthalter et al. 2005; Cakmak 2007).

The hearts, to which latex and corrosion casting model were applied and thus whose coronary arteries were uncovered, were photographed using Canon 350D DIGITAL camera.

RESULTS

Left coronary artery

In chukar partridges, it was determined that left coronary artery (Figures 1, 2, 3, 4, 5) was originated just above left semilunar valve over the ostium aorta. It was determined that the root of pulmonary trunk was located as embedded in the adipose tissue in the left ventral section of coronary groove. Left coronary artery was divided into two as profound branch and superficial branch (Figure 6). Left circumflex branch was a short and small branch that continues from left superficial branch to caudal. The larger and longer branch that coursed towards caudal was interventricular paraconal branch (Figure 7).

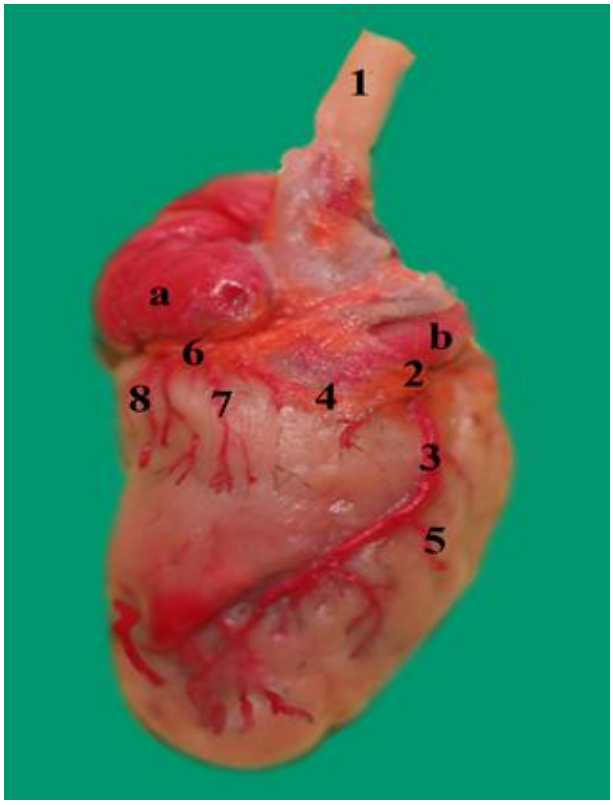

Figure 1. The branches of right and left coronary arteries in partridge (latex)

1. Aorta, 2. Right coronary artery, 3. Interventricular subsinuosal branch, 4. Right circumflex branch, 5. Left distal ventricular branch, a. Left auricle, b. Right auricle, 6. Left coronary artery, 7. Profound branch, 8. Superficial branch,

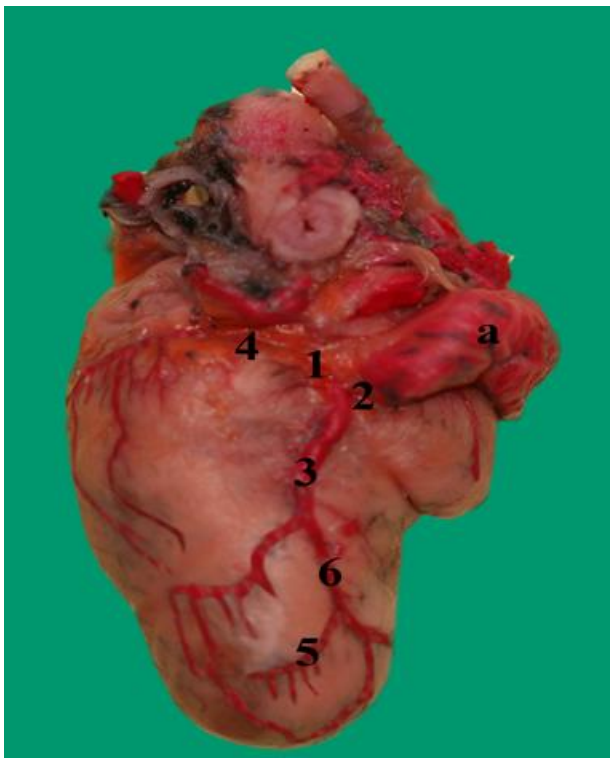

Figure 2. The left coronary artery of partridge (latex)

a. Left auricle, 1. Left coronary artery, 2. Superficial branch, 3. Profound branch, 4. Left circumflex branch, 5. Ventricular branches, 6. Interventricular paraconal branch

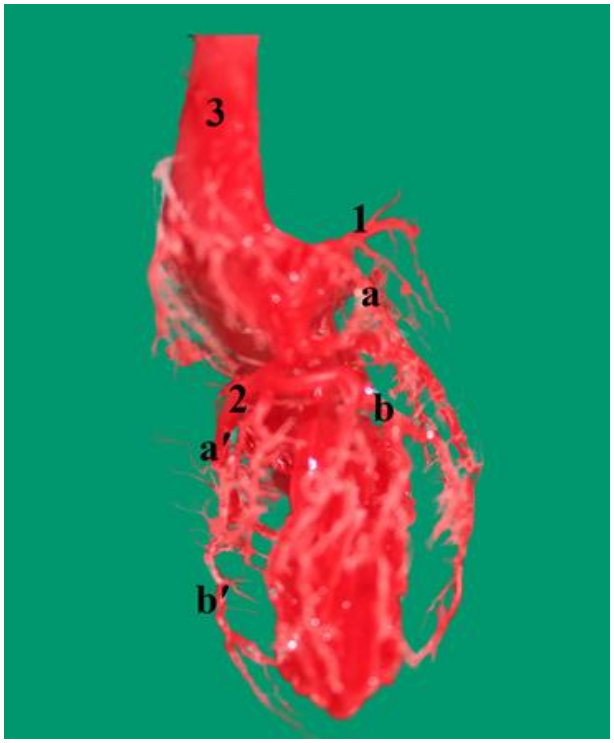

Figure 3. The left and right coronary arteries of partridge (corrosion cast)

1. Left coronary artery, a. Left circumflex branch, b. Interventricular paraconal branch, 2. Right coronary artery, a'. Right coronary artery, b'. Interventricular subsinuosal branch, 3. Aorta

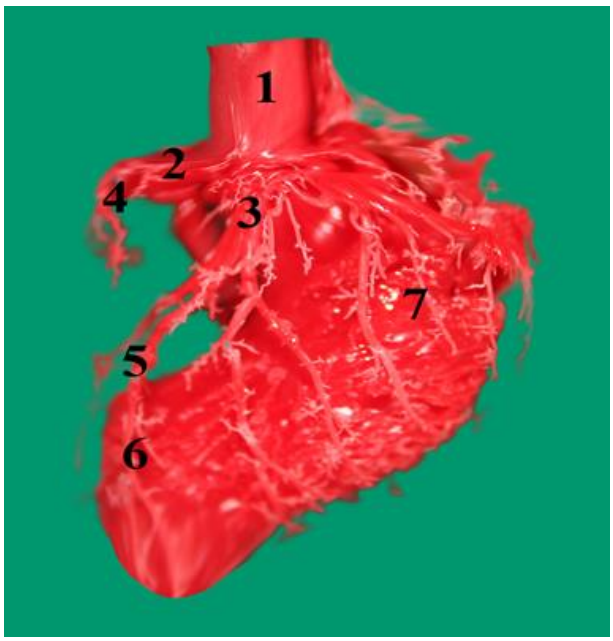

Figure 4. The left coronary artery, ventricular branches and atrial branches of partridge (corrosion cast)

1. Aorta, 2. Left coronary artery, 3. Conal arteriosal branch, 4. Left circumflex branch, 5. Interventricular paraconal branch, 6. Ventricular branches, 7. Atrial branches

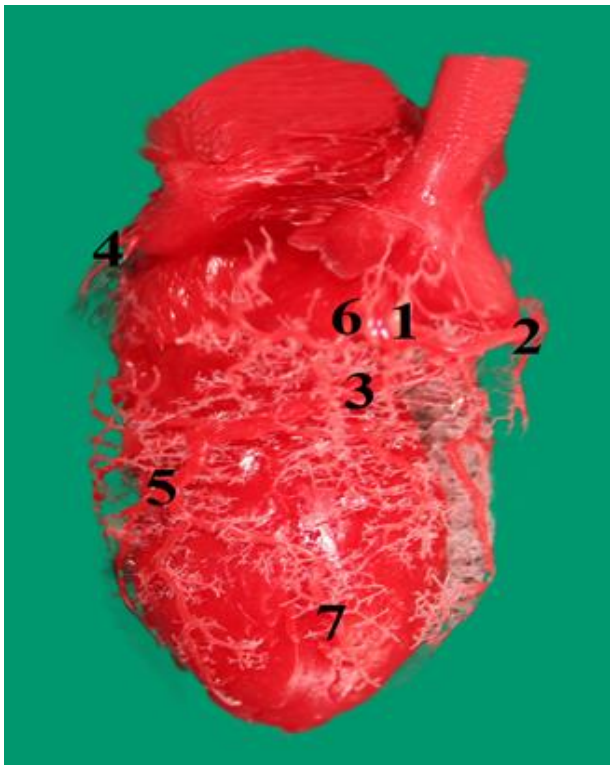

Figure 5. The left and right coronary arteries of partridge (corrosion cast)

1. Left coronary artery, 2. Left circumflex branch, 3. Interventricular paraconal branch, 4. Right coronary artery, 5. Interventricular subsinuosal branch, 6. Left atrial banch, 7. Left ventricular branch

It was specified that interventricular paraconal branch coursed paraconal interventricular groove (Figure 9). Also, left circumflex branch oriented towards the caudal and the left side by following the coronary groove on the left side of the heart. Interventricular paraconal branch gave ventricular branches both towards caudal and ventral

(Figures 2, 4). It was divided in two as left and right ventricular branches and it also supplied blood to the left and right ventricular walls. Atrial branch arose from left coronary artery (Figures 4, 5) and these supplied to pectinate muscles.

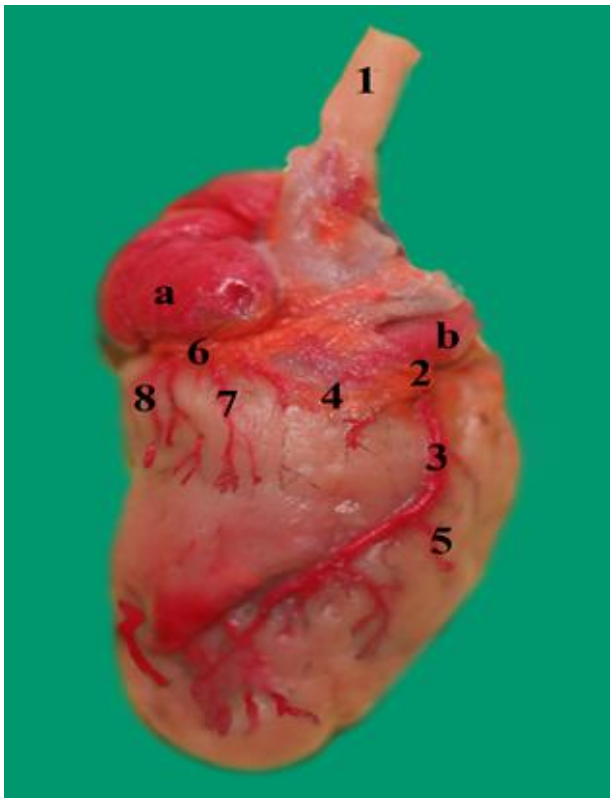

Figure 6. The branches of right and left coronary arteries of partridge (latex)

1. Aorta, 2. Right coronary artery, 3. Interventricular subsinuosal branch, 4. Right circumflex branch, 5. Left distal ventricular branch, a. Left auricle, b. Right auricle, 6. Left coronary artery, 7. Profound branch, 8. Superficial branch

It was observed that superficial branch gave conus branch where it was originated from left coronary artery (Figure 4). Left coronary artery entered in interventricular septum by dividing in numerous small branches supplying to the front side of interventricular septum. It was determined that these small branches named as septal branches supplied to interventricular septum.

It was seen that septal branches of left profound branch took place on the right root side of left coronary artery. These branches were parallel. Left profound branch was terminated by extending to the end of apex.

It was seen that another branch divided from left coronary artery was interatrial branch. Right interventricular branch coursed to right atrium and left interatrial branch coursed to left atrium so that they supplied to pectinate muscles.

Right coronary artery

It was determined that right coronary artery (Figures 1, 3, 8,) was originated over the free end of right semilunar valve on the ostium aorta in partridges. It was determined that after it was originated, it coursed towards coronary groove within fat layer. It was divided in two branches as superficial and profound (Figure 8).

It was determined that profound branch provided numerous septal branches that supplied blood to this area in interventricular septum. Profound branch could not be completely seen in right ventricle. Also it did not reach to the walls of the right and left ventricles and to the apex.

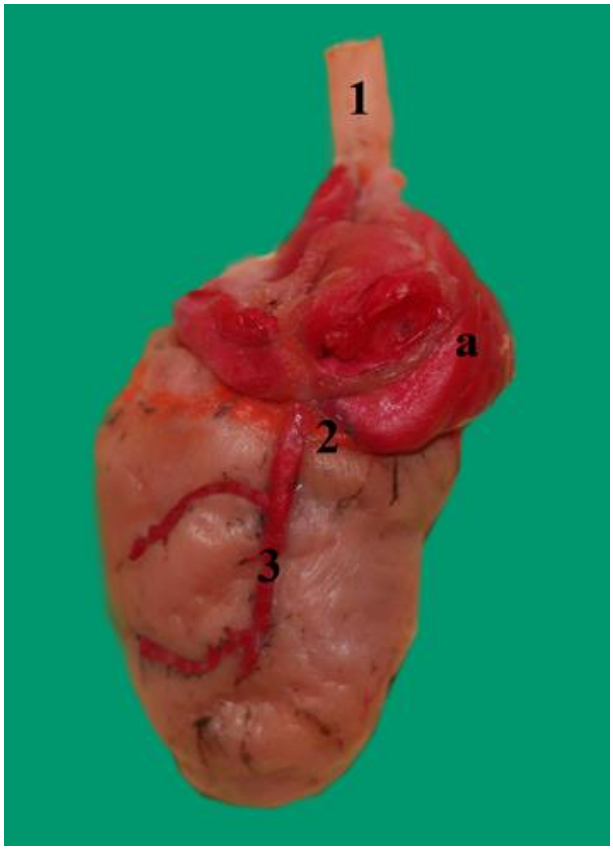

Figure 7. The left coronary artery of partridge (latex)

a. Left auricle, 1. Aorta, 2. Left circumflex branch, 3. Interventricular paraconal branch

It was determined that superficial branch in its course at coronary groove on the surface of the heart it was divided in one or two branches named as conal branches. These branches supplied to the base section of conus arteriosus and pulmonary trunk. It was seen that it anastomosed with the same branch arising from left coronary artery. Superficial branch continuing in coronary groove was converted into circumflex branch (Figures 1, 3, 9). Circumflex branch gave ventricular branches towards the lateral and the ventral. These branches carried blood to the ventricles. Ascending and descending branches of atrial branches were separated from right circumflex branch.

It was seen that right circumflex branch gave interventricular subsinuosal branch in subsinuosal interventricular groove (Figures 1, 3, 5). This branch was divided in two branches and one of them gave numerous branches to the apex and the other parts of left ventricle.

DISCUSSION

Zeren (1971), Adams and Treasure (1985), Sans-Coma (1989), Moore (1992), Lo et al. (1994), Cavalcanti et al. (1995), and Ishzawa (2006) revealed the presence of left coronary artery and right coronary artery in the human heart in their studies. Nickel et al. (1981), Karadag and Soyguder (1989), Dursun (1994), and Teixara et al. (2001), reported in their studies on the cattle heart that the heart was supplied by two main arteries and these veins were left coronary artery and right coronary artery. In the studies on the goat heart, it was specified that the heart was supplied by right coronary artery and left coronary artery

(Chakravarthy and Sastry 1979; Nickel et al. 1981; Lipovetsky et al. 1983; Tipirdamaz 1987; Yang et al. 1989; Machado et al. 1995). Ocal and Cakır (1993) revealed the presence of left coronary artery and right coronary artery in the ox heart. It was determined that the sheep heart was supplied by two arteries (Nickel et al. 1981; Tipirdamaz 1987; Dursun 1994, Teke et al. 2017).

Nickel et al. (1981) and Aksoy (2000) reported that the heart of the cat was supplied by right coronary artery and left coronary artery. It was revealed that the same veins provided the blood supply of the heart in dogs (Christensen and Campeti 1959; Dursun 1979; Nickel et al. 1981).

It is reported that there are two arteries supplying the heart in horse (Nickel et al., 1981), pig (Christensen and Campeti 1959), castor (Bisaillon 1981), donkey (Dursun 1977; Ozgel et al. 2004; Ozgel and Dursun 2005), mice (Icardo and Calve 2001), humped camel (Ghazi and Tadjelli 1993), Dromedary Camel (Podesser et al. 1977; Taha and Abel-Maged 1996), rabbit (Aksoy 2000), porcupine (Atalar et al. 2003) and these aortae are right coronary artery and left coronary artery.

It is revealed that the coronary arteries are the branches originating from left coronary artery and right coronary artery in poultry (Hodges 1974), domesticated birds (Nickel et al. 1977), poultry (Baumel 1975), ostrich (Bezuidenhout 1984), and turkey (Cakmak 2007). In the study conducted on the partridge heart, it was determined that the coronary arteries were right coronary artery and left coronary artery.

It is reported that left coronary artery is originated from aortic sinus (Zeren 1971; Moore 1992; Arinci and Elhan 1995). Left coronary artery is originated from bulbus aorta in horse (Nickel et al. 1981; Ozgel et al. 2004), and from the left sinus in aorta in donkey (Dursun 1977). Left coronary artery is originated from aorta at the left semilunar valve level (Chakravarthy and Sastry 1979, Lipovetsky et al. 1983; Tipirdamaz 1987). It is determined that this artery is originated from the bulbus aorta in cattle (Nickel et al. 1981), from aorta in buffalo (Tecirlioglu et al. 1977; Dursun 1978) and from the beginning level of aorta in a study conducted on Eastern Anatolian Red Cattle (Karadag and Soyguder 1989). Left coronary artery is originated from the left aortic sinus in Akkaraman sheep (Tipirdamaz 1987), cat (Aksoy 2000) and dog (Nickel et al. 1981), pig (Dursun 1975; Nickel et al. 1981; Weaver et al. 1986) and it is both longer and wider than right coronary artery. Dursun (1979) has reported that left coronary artery of dog is thicker than its right coronary artery. It is reported that the left coronary artery is thicker than the right coronary artery in Eastern Anatolian Red Cattle (Karadag and Soyguder 1989), donkey (Ozgel et al. 2004) sheep and goat (Chakravarthy and Sastry 1979; Tipirdamaz 1987).

The studies conducted on the heart in poultry (Baumel 1975), domesticated birds (Nickel et al. 1977; Dursun 2002), and turkey (Cakmak 2007) have indicated that left coronary artery is originated from the aortic sinus. In the partridge heart, left coronary artery is originated from the aortic ostium level.

It is reported that left coronary artery in cattle, horse, pig, cat, and dog is divided into two as interventricular paraconal branch and left circumflex branch (Nickel et al. 1981). While in a goat study it is expressed that left coronary artery is divided in two branches as interventricular paraconal branch and left circumflex branch (Chakravarthy and Sastry 1977), the study conducted by Tecirlioglu et al. (1977) on the buffalo heart reveals that left coronary artery is divided in two branches as interventricular paraconal branch and left circumflex branch. It is reported that left circumflex branch and the thinner interventricular paraconal branch are originated from left coronary artery in Eastern Anatolian Red Cattle (Karadag and Soyguder 1989).

In domesticated birds (Nickel et al. 1977) and poultry (Baumel 1975), left coronary artery is divided in two as profound branch and superficial branches after its short root. In ostrich, left coronary artery gives profound branches, which can be between 1-4 after their origin, courses towards the ventral, and then continues as superficial branch (Bezuidenhout 1984). In a study conducted on turkey, it was determined that left coronary artery was divided as profound branch and superficial branch around its root (Cakmak 2007). In domesticated birds, superficial branch was stated to course towards atrial surface by entering in coronary groove and thus give interventricular paraconal branch and left circumflex branch (Nickel et al. 1977). Superficial branch continues towards the dorsal of the pulmonary root on the left side of coronary groove in poultry (Baumel 1975). In this study, the presence of interventricular paraconal branch and left circumflex branch was determined.

It is reported that in horse, left circumflex branch extends towards atrial surface of heart and gives 5-7 branches to supply to left ventricle and these branches are also named as left ventricular marginal branch, left intermediate atrial branch, left proximal atrial branch, and angular branch (Nickel et al. 1981). It is also specified in the literature that left circumflex branch gives left ventricular proximal branch and left proximal atrial branch in cattle (Nickel et al. 1981; Karadag and Soyguder 1989; Dursun 1994). Left circumflex branch courses within paraconal interventricular groove in poultry (Baumel 1975), ostrich (Bezuidenhout 1984), domesticated cock (Lindsay and Smith 1965), and domesticated birds (Nickel et al. 1977) and these results are compatible with this study.

In a study conducted on Eastern Anatolian Red Cattle, it is reported that interventricular paraconal branch courses in interventricular paraconal groove, reaches to apex cordis, crosses to the right atrial face of heart, anastomoses with the branches of interventricular subsinuosal branch and also gives left and right ventricular branches throughout its course in the groove (Karadag and Soyguder 1989). This feature is also valid for the birds (Hodges 1974; Baumel 1975). In this study, it was determined that this branch coursed in paraconal interventricular groove and gave branches to the right and left ventricles.

In a study conducted on turkey heart, it is found that left coronary artery enters in the interventricular septum in the area where it is divided in numerous small branches supplying to the cranial part of interventricular septum (Cakmak 2007). In an ostrich study, the presence of septal branches was revealed (Bezuidenhout 1984). These study results are parallel with the result indicating that septal branches are separated from profound branch of left coronary artery and supplies to interventricular septum (Baumel 1975).

In the study conducted by Karadag and Soyguder (1989) on Eastern Anatolian Red Cattle, they reported that right coronary artery was originated from the upper side of the right semilunar valve and from the beginning level of the aorta. In goats, right coronary artery was originated from the aorta (Chakravarthy and Sastry 1979; Lipovetsky et al. 1983; Tipirdamaz 1987).

In an ostrich study, it was reported that right coronary artery was originated from the right aortic sinus

(Bezuidenhout 1984). While right coronary artery is originated from right aortic sinus in poultry (Baumel 1975), it is originated from right semilunar valve sinus in domesticated birds (Nickel et al. 1977). In the turkey study by Cakmak (2007), it was determined that right coronary artery was originated from just above the right semilunar valve in aortic ostium. The results of the present study are compatible with the results of the turkey study by Cakmak (2007).

In an ostrich study, it was reported that right coronary artery reached to the cranial of the right auricle on the right side and to the base of the pulmonary root on the left side and to the conus arteriosus, gave profound branch near to its origin, and continued as a superficial branch (Bezuidenhout 1984). In poultry, it was specified that while right coronary artery gave profound and superficial branches while continuing towards the ventral in coronary groove (Baumel 1975). In this study, it was observed that after the right coronary artery coursed towards the ventral in the coronary groove as covered with an adipose tissue and right auricle, it gave profound and superficial branches.

In this study, it was observed that the profound branch gave septal branches that supplied to interventricular septum. In addition to septal branches, profound branch also gives conus branch in dog (Nickel et al. 1981). Cattle also has right ventricular marginal branch and right ventricular proximal branch (Nickel et al. 1981). The presence of this branch, called as conus branch and known as a single branch was mentioned in buffalo by Tecirlioglu et al. (1977), in Eastern Anatolian Red Cattle by Karadag and Soyguder (1989), and in domesticated mammals by Nickel et al. (1981). The presence of conus branch in the bird heart was reported (Baumel 1975). In the present study, it was revealed that right coronary artery coursing in coronary groove gave one or two branches named as conal branches.

As reported in the studies on poultry (Baumel 1975; Nickel et al. 1977; Bezuidenhout 1984), it was observed in this study that right circumflex branch was the continuation of superficial branch. In domesticated mammals and poultry, it was reported that circumflex branch gave a large branch called as interventricular subsinuosal at the place where it reached to the interventricular subsinuosal groove (Baumel 1975; Tecirlioglu et al. 1977; Nickel et al. 1981; Tipirdamaz 1987). The results of the study revealed that several atrial branches were observed besides the ventricular branches separating from right circumflex branch. This result is similar to the data obtained for domesticated mammals and birds.

While Nickel et al. (1977) reports that interventricular subsinuosal branch is divided into two branches in domesticated birds, Baumel (1975) states that interventricular subsinuosal branch is divided into two branches in poultry. In the present study conducted on the heart of partridge, the presence of interventricular subsinuosal branch was found. Also, this branch was divided in two arms and one of these arms gave numerous ventricular branches to left ventricle.

Consequently, the heart is supplied by two main arteries as left coronary artery and right coronary artery that are originated from aortic sinus. Left coronary artery is originated from the left semilunar valve level of aorta. Left coronary artery is divided in two as profound branch and superficial branch. Left superficial branch gives left circumflex branch, which is small and shorter and courses to the caudal, and paraconal interventricular branch which is larger and the big one. Interventricular paraconal branch courses in paraconal interventricular groove. Ventricular branches and atrial branches arise from interventricular branch. Also, on the surface of the heart, left coronary artery gives conal branch. Profound branch, a branch of left coronary artery, gives septal branches to interventricular septum. Interatrial branch is another branch separating from left coronary artery.

Right coronary artery is originated from aortic ostium. Right coronary artery is divided into two as profound branch and superficial branch. Profound branch enters in interventricular septum. Superficial branch gives one or two branches called as conal branch. Also, the branches called as circumflex branch and interventricular subsinuosal branch are separated from superficial branch. Subsinuosal interventricular branch courses in subsinuosal interventricular groove towards the apex of the heart. Atrial branches supplying blood to atria and ventricular branches supplying to the ventricles also arise from right circumflex branch. The grooves on the surface of the heart are covered with subepicardial adipose tissue. Maximum fat mass is present in coronary groove.

Heart and coronary arteries of chukar partridge were determined to be similar to domesticated birds, ostrich, and other poultry animals. The branches arising from the coronary vessels in the chukar partridge were different from those in the mammals. This information, which is not included in the literature, appears the results of this study.

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Ethical report of the research project was approved by Yuzuncu Yil University Animal Researches Local Ethic Committee in the session held on 04/26/2108 (decision number 2018/04).

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