

The Coronary Circulation of the Heart of the Goose and Turkey Living at High Altitudes and Cold Climate Conditions

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Summary

In this study, distribution of the coronary circulation in 15 geese and 15 turkeys raised at high altitudes and very cold climate conditions in Kars and its provinces in Turkey, were defined and compared with existing literature on other bird species. The right and left coronary arteries in both species were roughly equally potent. The deep ramus of the right coronary artery and the superficial ramus of the left coronary artery were very thick in both species. The deep ramus of the left coronary artery in turkey was present as an individual vessel while it was as a subbranch of the superficial ramus in nature in goose. Yet, the septal rami of the deep rami of the right and left coronary arteries in turkey showed very eminent anastomoses while no anastomose was seen in the goose.

Keywords: Coronary arteries, Goose, Turkey

Yüksek ve Soğuk İklim Koşullarında Yaşayan Kaz ve Hindi Kalplerinin Koroner Arter Sirkülasyonu

Özet

Bu çalışmada, Kars ve çevresinde yüksek ve soğuk iklimde yetiştirilen 15 adet kaz ve 15 adet hindi kalbinde koroner sirkülasyonun dağılımı incelendi ve elde edilen bulgular literatürde var olan diğer kanatlı verileriyle karşılaştırıldı. Her iki kanatlıda da sağ ve sol koroner atardamarlar yaklaşık olarak aynı kalınlıkta gözlemlendi. Yine, her iki canlıda da, sağ koroner atardamarın derin dalı ve sol koroner atardamarın yüzlek dalı çok kalındı. Hindide sol koroner atardamarın derin dalı bağımsız bir damar olarak bulunurken, kazda bu damar yüzlek dalın bir alt dalı olarak gözlemlendi. Yine, hindide sağ ve sol koroner atardamarların derin dallarından ayrılan septal alt dallar arasında çok belirgin ağzlaşmalar belirlenirken, kazda böyle bir durum gözlemlenmedi.

Anahtar sözcükler: Koroner arterler, Kaz, Hindi

INTRODUCTION

Birds comprise a very high-performance cardiovascular system to meet the rigorous demands of running, swimming and most of all flying. This system, thus, requires perfect transport capabilities to supply sufficient oxygen delivery to functioning vascular elements and to provide well-organized exclusion of metabolic products. Like wise, birds are homeothermic species whose cardiovascular system plays a key role in arranging body temperature ^{1,2}. This is particularly essential for the avian species that either live at very high altitudes and cold climate conditions or fly high. As might be expected, these demands have, at long

term, evolved components of the cardiovascular system of the birds in a way to collaborate in an integrated approach to make sure that oxygen delivery to the related organs matches the request.

Each coronary artery in avian species commonly divides in general into superficial and deep rami at various degrees after arising from its origin ^{1,3-6}. Unlike the condition in mammals, the main blood flow to the heart in avian species is supplied to myocardium through deep ramus. Most of the studies on the coronary circulation of avian species have mainly



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concentrated on the domestic fowl and other domestic birds, and have been performed on very few numbers of specimens. As to our knowledge, no study has focused particularly on the possible effects of the high altitude and very cold climate conditions in the coronary circulation of the birds. This study, therefore, has investigated in detail the coronary circulation of the geese and turkeys living at high altitude and very cold climate conditions, and has compared the data with available literature.

MATERIAL and METHODS

Fifteen fresh adult geese (*Anser anser*, 5 male, 10 female, weighing 2400-2800 gr) hearts and fifteen fresh adult turkeys (*Meleagris gallopova*, 5 male, 10 female, weighing 2600-3200 gr) hearts were firstly injected in retrograde fashion with red colored-latex (ZPK-582-G by Educational&Scientific Products Ltd, Rustington, West Sussex, UK) by ways of the aorta, under constant pressure. The sex of the species was disregarded since the preliminary observation showed no significant differences on the coronary artery patterns. The cadavers were then put in tap water for polymerization of the latex for 48 h and later were kept in 10% formaldehyde to protect them from decay. Finally, dissection was performed, the right and left coronary arteries were examined, and the vessels were counted macroscopically and by a loop.

Nomina Anatomica Avium 7 was followed for the anatomical nomenclature.

RESULTS

Both the right (*Fig 1/A; 2/A*) and left (*Fig 1/B; 2/B*) coronary arteries were potently equally well developed in all cadavers of both the goose and turkey. The right coronary artery in both species originated from the right wall of the aorta just dorsal to the right semilunar valve. The right coronary artery in the goose ran cranially to the right, then to the cranial aspect of the right auricle and base of the pulmonary trunk, and gave off the superficial ramus (*Fig 1/C*) and continued as the profundus ramus (*Fig 1/D*). In the turkey, however, it immediately sent off the superficial ramus (*Fig 2/C*) and coursed as the profundus ramus (*Fig 2/D*).

The superficial ramus in the goose, with a roughly one-fourth of the profundus ramus in thickness, coursed in the coronary groove, giving 3-4 atrial branches and 1-2 conal branches while it, with a

nearly one-third of the profundus ramus in thickness, sent 1-3 atrial branches and no conal branch in turkey. The artery in both species then continued as the circumflex ramus (*Fig 1/E; 2/E*). Along its course, it yielded several atrial and ventricular rami through the related areas. On reaching the subsinuosal interventricular groove, the circumflex artery in both species gave ventrally interventricular subsinuosal ramus which was very weak, not reaching the apex of the heart. It then ended by anastomosing weakly with the corresponding artery of the left coronary artery in the goose while no anastomose was seen in the turkey.

The profundus ramus in both species was apparently very thick, coursing as the continuation of the right coronary artery. It reached the interventricular septum, sending numerous septal rami to supply the septum. The septal rami showed very eminent anastomoses

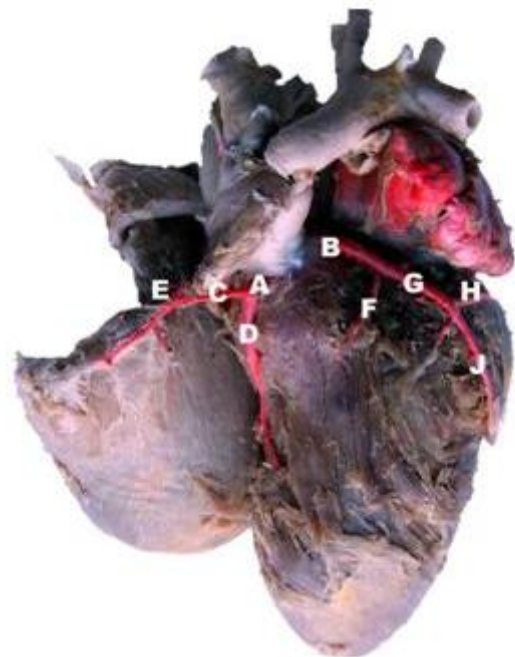


Fig 1. The coronary circulation of the heart of the goose

A- Right coronary artery, **B-** Left coronary artery, **C-** Superficial ramus of the right coronary artery, **D-** Profundus ramus of the right coronary artery, **E-** Circumflex ramus of the right coronary artery, **F-** Profundus ramus as a subbranch of the superficial ramus of the left coronary artery, **G-** Superficial ramus of the left coronary artery, **H-** Circumflex ramus of the left coronary artery, **J-** Interventricular paraconal ramus of the left coronary artery

Şekil 1. Kazda kalbin koroner sirkülasyonu

A- A. coronaria dextra, **B-** A. coronaria sinistra, **C-** A. coronaria dextra'ya ait ramus superficialis, **D-** A. coronaria dextra'ya ait ramus profundus, **E-** A. coronaria dextra'ya ait ramus circumflexus, **F-** A. coronaria sinistra'ya ait ramus superficialis'in bir alt dalı şeklindeki ramus profundus, **G-** A. coronaria sinistra'ya ait ramus superficialis, **H-** A. coronaria sinistra'ya ait ramus circumflexus, **J-** A. coronaria sinistra'ya ait ramus interventricularis paraconalis

with the corresponding rami of the left coronary artery in the turkey while no anastomose was seen in the goose. Distally, it nourished the ventricular musculature through giving off ventricular branches lateroventrally and medioventrally which possessed clear recurrent branches in the turkey. The recurrent branches were very weak in the goose. Finally, the septal rami did not reach the apex.

The left coronary artery in both species arose from the left wall of the aorta just dorsal to the left semilunar valve. Later, it coursed craniolaterally to the left, then to the craniodorsal aspect of the pulmonary trunk and dorsal to the left auricle. It first gave caudally 1-2 interatrial rami. The left coronary artery of the turkey then gave a potent profundus ramus (Fig 2/F) which directed ventrally and continued as the superficial ramus (Fig 2/G). However, it sent 1-2 smaller sub-



Fig 2. The coronary circulation of the heart of the turkey

A- Right coronary artery, **B-** Left coronary artery, **C-** Superficial ramus of the right coronary artery, **D-** Profundus ramus of the right coronary artery, **E-** Circumflex ramus of the right coronary artery, **F-** Profundus ramus of the left coronary artery, **G-** Superficial ramus of the left coronary artery, **H-** Circumflex ramus of the left coronary artery, **J-** Interventricular paraconal ramus of the left coronary artery, **K-** Anastomosing branches

Şekil 2. Hindide kalbin koroner sirkülasyonu

A- A. coronaria dextra, **B-** A. coronaria sinistra, **C-** A. coronaria dextra'ya ait ramus superficialis, **D-** A. coronaria dextra'ya ait ramus profundus, **E-** A. coronaria dextra'ya ait ramus circumflexus, **F-** A. coronaria sinistra'ya ait ramus profundus, **G-** A. coronaria sinistra'ya ait ramus superficialis, **H-** A. coronaria sinistra'ya ait ramus circumflexus, **J-** A. coronaria sinistra'ya ait ramus interventricularis paraconalis, **K-** Anastomozlaşan dallar

branches as the deep branch (Fig 1/F) in the goose and coursed as the superficial ramus (Fig 1/G).

The superficial ramus in both species coursed in the coronary groove. Along its course, it sent lateroventrally and medioventrally ventricular branches, but gave no conal branch. On reaching the paraconal interventricular groove, it divided into a smaller, caudally directed circumflex ramus (Fig 1/H; 2/H) and a larger ventrally directed interventricular paraconal ramus (Fig 1/J; 2/J). The circumflex ramus in both species coursed in the coronary groove, yielding the ventricular and atrial rami, and terminated by anastomosing with the corresponding branch of the right coronary artery in the turkey. This anastomose was not observed in the goose. The paraconal interventricular ramus descended in the paraconal interventricular groove sending bilaterally dorsally and ventrally directed ventricular rami. The rami were many in number in turkey as compared to the goose and also gave recurrent branches and reached the apex.

The profundus ramus was a potent, large vessel in the turkey. It descended to the interventricular septum, gave several atrial rami, and divided into several small branches. These branches had recurrent subbranches, and anastomosed with the corresponding branches of the superficial ramus of the left coronary artery and septal rami of the profundus ramus of the right coronary artery (Fig 2/K). They also reached the apex. In the goose, there was no real deep branch originating from the left coronary artery. Instead, a number of 1-2 subbranches arising from the superficial ramus vascularized the related area. They were small, had no recurrent subbranches, and did not reach the apex.

DISCUSSION

This study documented the coronary circulations of the geese and turkeys living at high altitudes and very cold climate conditions in Kars and its provinces, revealing that they fundamentally resemble to what has been accumulating in the related literature^{1,3-6}. Yet, in detail, they showed several differences not only between the two avian species but also among the individuals of the same species, based on the size, distribution pattern and supply area of the branches arising from the right and left coronary arteries.

Researches have indicated that presence of more than two coronary arteries is common in avian species capable of powerful flight^{8,9} while birds either having limited flight capacity or being flightless, display two

coronary arteries. Each of the coronary artery in birds has been reported to have a smaller superficial branch and a larger deep branch, and the right one is thicker in general ^{1,4-6}. The presence of larger deep branch has stressed the fact that, in contrary to mammalian condition, most of the blood supply to the heart of birds in particular those possessing powerful flight capacity is distributed to the myocardium through deep branch ¹⁰. It is indeed very interesting to note hereby that main blood supply to the heart of the ostrich, a flightless bird, is provided by the superficial rami of the coronary arteries ¹¹. Additionally, the superficial rami of the coronary arteries have been indicated to be larger in avian species that swim ⁹. Here presented two equally well developed coronary arteries only, arising from the aorta in both species. However, we observed in the turkey that the profund ramus was very large as compared to the superficial ramus in the right coronary artery, but vice versa in the left coronary artery. Like wise, the profund ramus of the right coronary artery in the goose was rather large while the profund ramus of the left coronary artery arose as 1-2 subbranches from the very large superficial ramus. The data acquired in this study indicate that the domestic goose and turkey two species possessing very limited flight capacity can rarely have more than two coronary arteries.

Upon the strict anatomical principles, the coronary arteries in mammals are considered not terminal arteries because they possess anastomoses with very narrow lumina ¹². On the other hand, as far as functional view-point is concerned, they are regarded as terminal arteries since the anastomoses are so narrow that can not adapt to thrombosis of a neighboring artery of which blood supply is in complete. We determined very eminent anastomoses which can be grossly seen between the septal rami of the profund rami of the right and left coronary arteries in the turkey. However, we did not observe such kind of anastomoses in the goose.

In summary, this study documented in detail the structural characteristics of the coronary arteries in the goose and turkey raised at higher altitudes and cold climate conditions. The right and left coronary

arteries in both species were roughly equally potent. The profund ramus of the right coronary artery and the superficial ramus of the left coronary artery were very thick in both species. Yet, there was a potent profund ramus in the left coronary artery in the turkey while it was as a subbranch in nature in the goose. There were apparent anastomoses between the septal rami of the right and left coronary arteries in the turkey even though no anastomoses were seen in the goose.

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