

BIODIVERSITY OF THE CORONARY ARTERIES IN CATTLE - MACROSCOPIC STUDY

**Iulian DUMITRESCU*, Gabriel PREDOI, Cristian BELU, Bogdan GEORGESCU,
Petronela ROȘU, Florina DUMITRESCU**

Faculty of Veterinary Medicine, 105 Splaiul Independenței, District 5, 050097. Bucharest, Romania

*Corresponding author: dumitrescu_julian@yahoo.com

Abstract

Lately, experimental medicine used the ruminants as experimental animals. On the sheep were achieved even heart experimental surgery. However, the literature about the vascularization of the heart is not very numerous especially regarding large ruminants. This study was conducted to provide supplementary data for the literature. The study was carried out on a total of 12 specimens in which the hearts were dissected after insertion into the arteries of the contrast dye. It has been found that right coronary artery is smaller than the left. Subsinusal branch is given by left coronary artery, being an extension of the left circumflex branch in subsinusal groove. Right ventricular wall is crossed by 5-6 main collaterals of right coronary artery, some of their terminal branches showing anastomosis with corresponding branches of the paraconal branch of the left coronary artery. Right coronary artery is much better represented than the left. Its terminals have a size nearly equal.

Key words: cattle, heart, coronary arteries.

INTRODUCTION

Besides the experimental surgery on pig, some authors (Shofti et al., 2004) used the sheep as experimental model.

The use of sheep as an animal model seemed to be ideal for simulating human cardiac surgical procedures due to the size of the chest cavity, which can accommodate devices and surgical instruments intended for human use. Due to the human-sized and comparable anatomical distribution of the coronary arteries, similarity in diameter of the left and right internal thoracic arteries (LITA and RITA), and ease of harvesting saphenous veins of suitable length and diameter, makes the sheep a more suitable model for such purposes (Shofti et al., 2004; Hill, 2015)

Talking about heart anatomy in cattle there are works on histological structure of the coronary arteries (Bylina, 2004; Ocala, 1993) or cardiac innervation (McKibben, 1969) but data are not very numerous regarding the cardiac vasculature (Bhargava, 1970). For this reason a detailed macroscopic study of coronary arteries in cattle was conducted.

MATERIALS AND METHODS

The research was conducted on 12 hearts from slaughtered animals. The weight of animals ranged between 90 and 150 kg. After collecting, the hearts were washed with water, including cavities. It was aimed to eliminate the residual blood present in the lumen of the coronary artery by compressing them from the terminal to the origin. Subsequently, the contrast substance (AGO) was introduced in the coronary arteries at the level of the aortic bulb. Injected pieces were placed in 10% formalin solution for one week. After washing to remove formaldehyde they have been dissected by the classical method. Latter the most representative pieces were photographed. Identification and description was achieved using *Nomina Anatomica Veterinaria* - 2005.

RESULTS AND DISCUSSIONS

The morphology of right coronary artery

The right coronary artery arises from the cranial part of the aortic bulb and is directed cranially, on the right side of pulmonary arterial trunk, between this and the right auricle.

After reaching the coronal sulcus, it is located at the ventral side of the right atrium, then, engages in the coronary groove on the atrial surface of heart. It does tortuous course at the base of the right atrium, up to subsinusal interventricular groove.

The first collateral issued by right coronary artery, is voluminous. It is directed at an acute angle, on the left side of this.

This collateral emits near the origin a branch detached from its right side, in the upper third of the cranial edge of the right ventricle.

Subsequently, the first collateral of the right coronary artery emits a flexion relatively smooth branch, reaching the origin of previous third of the right side of pulmonary arterial trunk.

Finally, the terminal trunk of the first collateral of the right coronary artery branch out in the upper third of the right ventricle, ventrally to the pulmonary trunk origin.

It is distributed in the arterial cone and intertwines with branches issued by the left coronary artery that supplies the same portion of ventricular mass.

The second collateral of the right coronary artery originates also from the right side of the main trunk at the front end of the coronal sulcus. This arises from a caliber similar to the first collateral. After a trajectory of 2 cm, emits a deeper branch descending in the thickness of the previous wall of the right ventricle and a superficial branch. The latter has an oblique path, descending to the left, focusing to paraconal groove that it meets horizontally at the line between the middle third and distal third of it. On his path, the collateral emits branches that can be drawn from both right and left sides on the main trunk. Through its distribution represents the main artery that supplies the auricular side (left) of the right atrium.

Third collateral is emitted by the right coronary artery close to the previous artery and has about the same caliber at origin with it. It comes down on cranial rim of the right ventricle having a rectilinear path. On the path it emits superficial branches detached from the both sides (right and left) and deep branches. Superficial branches, averaging four on each side, have obliquely and descendant path, covered with thin myocardial bundles. Two or

three deep branches are detached from the deep side of the main trunk and lost in ventricular wall thickness. The last distal ramifications of the main trunk of the third collateral of the right coronary artery are exhausted at distal end of cranial rim of the right ventricle. Through its distribution this collateral ensures dominant arterial irrigation of cranial rim of the heart.

Next, right coronary artery emits 2-3 short collaterals, from the previous rim, that supply the upper third of the cranial rim of the heart. Opposite to these branches, originating on the back side of coronary artery, constantly emerge ventricular upper branches relatively short and fine that supply the previous coronary rim of the right ventricle and is exhausted before reaching the base of the right atrium (Fig. 1).

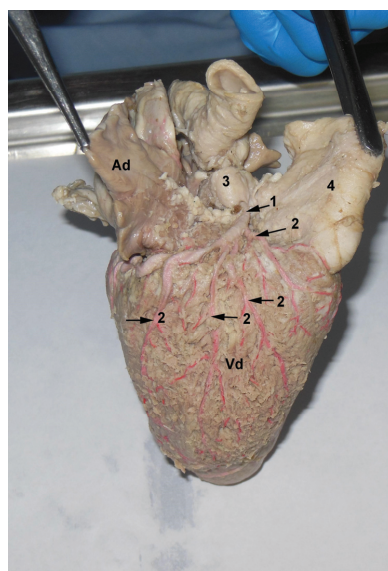


Fig. 1. The origin of the right coronary artery- dorsocranial view of the heart (original)
1- right coronary artery; 2- the main ventricular branch; 3- aortic bulb; 4- pulmonary trunk;
Ad- right atrium; Vd- right ventricle

The main atrial collateral (proximal atrial artery) is emitted by the right coronary artery from its caudal edge and addresses the eccentric wall of the right atrium. This collateral emits a descending atrial branch which goes down to the base of the right atrium being exhausted into the coronary groove. Subsequent, the proximal atrial artery has a path with flexion and caudal dorsal oblique,

reaching to the level of openness of the caudal vena cava. On its way emits 2-3 ascending branches which are distributed to the right wall of the right atrium, the first of these branches, focusing cranial to the ventral edge of the right auricle (Fig. 2).

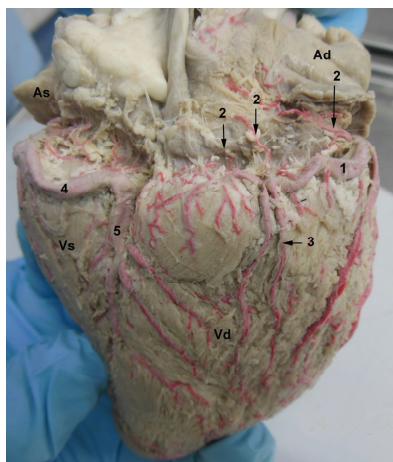


Fig. 2. The terminal branches of the right coronary artery on the right side of the heart (original)

1-the right coronary artery; 2- atrial branches; 3- ventricular branches; 4- left circumflex branch; 5- subsinuous branch; Ad- right atrium; As- left atrium; Vd- right ventricle; Vs -left ventricle

Opposite the place of detachment of proximal atrial artery from the right coronary artery emerges a strong ventricular distal branch, which obliquely descends at superficial level to the top of the right ventricle, approximately halfway between the cranial edge of the heart and subsinuous groove. This emits 2-3 fine collaterals from its right side and 4-5 branches thicker and longer from its left side.

The last of these branches descend obliquely the paraconal groove and will anastomoses with an ascending branch of interventricular paraconal artery. Through its distribution path this collateral of the right coronary artery ensures irrigation of the previous third of atrial side of right atrium (fig. 3).

After issuing this collateral, the right coronary artery emits distally 3-4 short and fine collaterals to the top edge of the right ventricle, and medial proximal emits branches to the ventral edge of the eccentric wall of right atrium.

The last of these atrial branches is better represented artery and is exhausted to atrial wall, dorsal to the opening of coronary sinus.

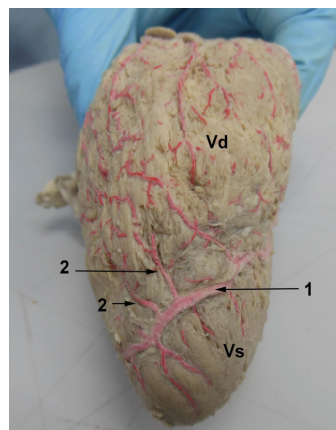


Fig. 3. The anastomosis between paraconal branch and ventricular branches of right coronary artery (original)

1- paraconal branch; 2- ascending branches (right ventricular) from the paraconal branch; Vd(Rv)- right ventricle; Vs(Lv)-left ventricle

The last two ventral collaterals of the right coronary artery often are detached as a common trunk, very short. Subsequent, they have a descendant path and slightly with flexion, oriented to the top of the heart. Through their branches, these two collaterals of the right coronary artery irrigate the middle third of the previous wall of the right ventricle. After issuing the last two powerful ventricular collaterals, the right coronary artery leads through the coronary groove with an atrioventricular branch called right circumflex branch. This branch is distributed as a tree, emitting both ventricular branches for the coronary end of right ventricle, and atrial branches addressing ventral edge of the eccentric wall of right atrium. The finest ramifications reach the upper end of subsinuous groove.

The morphology of left coronary artery

Emerges from the left side of the aortic bulb and switches to the caudal edge of the pulmonary arterial trunk. At origin, it has almost double size of the right coronary artery. After a short path (about 2-3 cm), it reaches the paraconal groove, where it ends with a paraconal branch and a circumflex branch (Fig. 4).

At this level, from the cranial edge of the coronary artery emerges a long and relatively thin branch that engages the left side of the origin of the pulmonary trunk, reaching its cranial side.

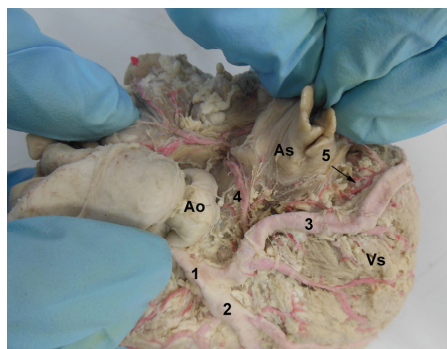


Fig. 4. The left coronary artery's terminals in coronary groove (original)

1-left coronary artery; 2-paraconal branch; 3- left circumflex branch; 4,5- the atrial branch of the left circumflex artery; Ao-aorta; As(La)- left atrium; Vs(Lv)- left ventricle.

The paraconal branch is placed in the paraconal groove, having a descendant ventro-cranial path. Near the top of the heart intersects its cranial edge, reaching the atrial side, until the distal end of the subsinusal groove. On the way, emits collateral both from the cranial edge and on the caudal edge.

Near the origin (about 0.5 cm), emits a collateral that emerges at right angle from the cranial edge. After a short path (about 1 cm) the latter will emit a dorsal branch, which will focus cranial, at a distance of approximately 0.7 cm ventral to coronal sulcus. This branch emits collaterals detached both from the upper edge and from the ventral edge (Fig. 5).

Last ramifications of this branch reach the upper third of the auricular portion of the right ventricle, ventral to the origin of pulmonary trunk. These branches are intertwined with those given by the first collateral of right coronary artery.

Through the distribution of its ramifications this artery provides irrigation of the right ventricle in the middle third of the auricular side of it. Next 3-4 cranial collaterals issued by paraconal artery are relatively thin and penetrate the ventricular mass reaching interventricular septum.

The second well represented collateral, detached from the cranial edge of paraconal artery, visible subepicardic, has a horizontal path to the cranial edge of the heart. It is highlighted on the auricular side of the right ventricle, at the boundary between the middle third and the bottom third of it.

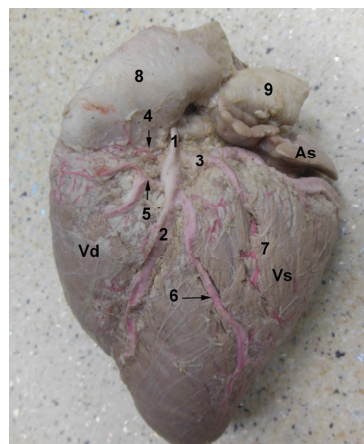


Fig. 5. The left coronary artery's terminals of the auricular face of the heart (original)

1-left coronary artery; 2-paraconal branch; 3- left circumflex branch; 4-collateral branch of left coronary artery; 5-right ventricular collaterals of the paraconal branch; 6- left ventricular collaterals of the paraconal branch; 7-the first ventricular collateral of the left circumflex branch; 8- pulmonary trunk; 9-aorta As(La)- left atrium; Vd(Rv)-right ventricle; Vs(Lv)- left ventricle.

At the level at which the paraconal groove intersects the cranial edge of cord the paraconal branch emits a well-represented collateral with an ascendant path toward the right side of cord. This branch will anastomoses with one of ventral collaterals issued by the right coronary artery (Fig. 3).

Next, the paraconal branch passes on to cranial edge of the cord near its peak, then gets the right side being exhausted at the ventral end of subsinuos groove. During this pathway the paraconal branch emits from its cranial side 4-5 collaterals with ascendant trajectory, which is distributed in the lower middle third of cranial edge of cord and ventral end of the right ventricle, on the atrial side of it.

Paraconal branch emits the following caudal collaterals:

The first collateral is detached from the caudal edge of paraconal branch, about the same level with the first cranial collateral. By its size and scope it is the most powerful of collaterals of terminal branches of the coronary arteries. It emerges in acute angle and then focuses to the caudal edge and the top of the cord, with a descendant path and oblique, caudal ventral.

At origin this collateral emits a branch that is distributed to left ventricle on the ventral portion at the intersection of paraconal groove and coronal sulcus. Still from the main arterial trunk emerge superficial branches both from the cranial edge (3-4) and deep branches, which penetrate the thickness of the left ventricle. Finally, the main trunk of this first caudal collateral ends forked, near the caudal edge of the cord. The two terminal branches originate from the same caliber. The upper end branch has a horizontal path, crossing the caudal edge of the heart at the line between the middle third and the bottom third of it, and finally arrives on the right side of left ventricle, ending near subsinusal groove. The descendant terminal branch descends to the top of the heart, where it branches and provides irrigation to its rear half. In conclusion, the first caudal collateral of paraconal artery is the main artery supplying auricular half ventral portion of the left ventricle, ventral half of the caudal edge of the cord and the rear portion of the peak of heart. At the top of heart, the terminal branches of paraconal artery intertwined with terminal branches of this first caudal collateral described. The next 3-4 collaterals detached from the caudal edge of the paraconal branch are relatively short (1 to 3 cm) and thin, have an oblique and descendant path caudal ventral, exhausting in the ventral third auricular portion of the left ventricle. In the terminal portion, the paraconal branch emits from the caudal margin 4-5 collaterals which descend to the top of the heart, thereby ensuring dominant irrigation of apex.

Circumflex branch presents at origin, a caliber similar to the paraconal branch. It is caudal oriented, following the coronary groove. Initially is located ventral to the left auricle, then to the ventral edge of the left atrium, until the caudal edge of it.

Subsequent, passes to the atrial side of heart, and at the proximal end of the subsinusal

groove goes down through this groove as a subsinusal branch.

With a long trajectory, circumflex branch emits collaterals both from the atrial and ventricular edge, the latter being more numerous and more voluminous. The main collaterals emitted from the ventricular edge of heart, have a descendant path and are distributed in the upper half of the posterior wall of the left ventricle.

The first of these is the most developed collateral. It is oriented ventral caudal and after a trajectory of 2-3 cm, bifurcate acute angle, branches being approximately equal. Through its distribution, this collateral supplies the higher part of proximal half of auricular side of the left ventricle.

Next 3-4 collaterals emitted by circumflex branch from her lateral side are short and relatively fine branches that are lost in left ventricle mass near the coronal sulcus.

The second well represented collateral detached from the ventricular edge of circumflex branch has also an oblique path, focusing distal also to the right side to get approximately to the half caudal edge of the heart. At the caudal edge of the left ventricle from the circumflex branch, emerges a collateral which after a short trajectory of about 0.5 cm, bifurcate acute angle and is distributed in the upper third of the caudal edge of the left ventricle (Fig. 6).

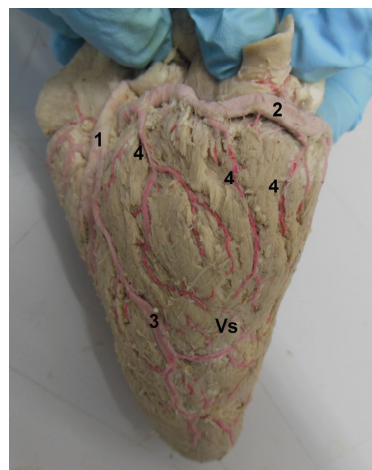


Fig. 6. Ventricular collaterals of the left coronary artery - caudal view (original)

1-paraconal branch; 2- left circumflex branch; 3- ventricular branch of the paraconal artery; Vs(Lv)- left ventricle.

The following strong collateral branch (the second in volume) that emerges from the ventral edge of circumflex branch is represented by intermediate branch, which descends through the caudal groove of the heart. Finally it is finished bifurcated. It is the main artery that supplies the upper half of the parietal wall of the left ventricle.

After issuing marginal artery, circumflex branch passes to the atrial side of coronary groove. At about 0.5 cm of the origin of the interim artery emits the better represented collateral that is distributed in the upper third of the atrial side of the left ventricle.

The collaterals detached from the atrial edge of circumflex branch generally have a horizontal or ascendant trajectory and is distributed dominant to the left atrium. The first of these collaterals is best represented. It is committed to the caudal edge of the aortic bulb, ventral of left auricle in which emits 3-4 arterials, then branching giving cranial branches which are distributed in right atrium ceiling, medium branches that supply the concentric wall of the cranial vena cava at its opening in the right atrium and caudal branches that are distributed on the right side of left atrium and pulmonary veins

Next collateral detached from atrial edge of circumflex branch is located about 3 cm caudal from the previous and is oriented to the base of left atrium on its auricular side where it ends forked with a cranial and caudal branch.

At the caudal edge of the heart, the circumflex branch emits stronger collateral, from which initially emerge branches that guides cranial, to the left base of left atrium and entering the upper edge of the left ventricle from the coronal groove. Next atrial branch of this collateral goes up to the ventral side of the caudal end of the left atrium in which branches. After issuing this branch, emitted by circumflex artery collaterals path will be through the coronary trench right to the left atrium near the base of the trench subsinusal origin. On the trajectory, it emits 3-4 branches atrial addressing the ventral edge of the left atrial wall on the right, and 2-3 branches ventricular finer entering the top edge of the left ventricle from the coronal trench.

Through this collateral, the circumflex branch supplies the portion of the left atrium located caudal and ventral to opening place of the pulmonary veins. Last collateral of circumflex branch, before engaging to subsinusal groove, ends branched at coronal sulcus by fine and ventricular branches.

Subsinusal branch appears as terminal part of circumflex branch in the subsinusal groove which it pursues near to the top of the heart. On its path, emits collaterals that fall both from the cranial and caudal edge of the main trunk and of its deep side (Fig. 7).

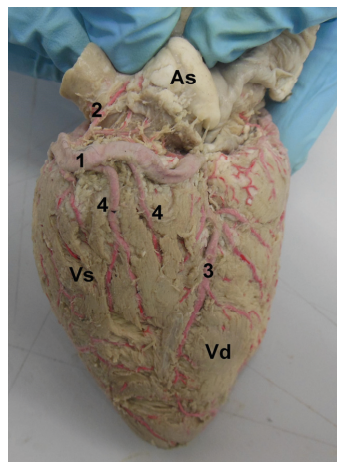


Fig. 7. Distribution of left circumflex branch-
caudolateral view of right side (original)
1- left circumflex branch; 2- atrial branch; 3-
subsinusal branch from 1; As – left atrium;
Vs(Lv)- left ventricle; Vd- right ventricle

There are three or four cranial collaterals with an oblique trajectory cranio-ventral and have an average length of 3-4 cm. They provide irrigation of anterior wall of the right ventricle on the portion located previous to the subsinusal groove.

Caudal collaterals, numbering two or three, are shorter and finer ending each bifurcated into the right end of the left ventricle.

Collaterals detached from the deep side of subsinusal branch penetrate the thickness of the ventricular myocardium and are exhausted into the interventricular septum.

CONCLUSIONS

Right coronary artery is smaller than the left and did not reach the origin of subsinuos groove. Ventricular collaterals are bulky and numerous. They irrigate almost entirely right ventricular wall. For this reason the right ventricular collaterals of paraconal branch are reduced.

The two terminals of the left coronary artery are equal. About two thirds of three of the left ventricle is mostly irrigated by strong collateral of the paraconal branch. Upper third is supplied by the first collateral of the left circumflex branch.

After issuing four voluminous ventricular collaterals, circumflex artery continues into the subsinusal groove with the homonymous branch.

This species have been identified anastomose visible to the naked eye between the terminal branches of the arterial tree.

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