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MACROSCOPIC RESEARCH REGARDING THE MORPHOLOGY OF THE CORONARY ARTERY ON DOMESTIC PIG

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Abstract

The importance of knowing the detailed morphology of organs in this species result from the fact that currently, the domestic pig is becoming increasingly used in xenotransplantation. Most investigators agree that pigs have the potential to be the prime candidates for organ donation. Pigs are plentiful, are quick to mature, breed well in captivity, have large litters, and have vital organs roughly comparable in size to those of humans. The study was carried out on a total of 15 specimens in which the hearts were dissected after insertion into the arteries of the contrast dye. It has found a relative morphometric equality between the two coronary arteries. Right ventricular wall was irrigated primarily by the branches of the common trunk of the right coronary artery but also by paraconal branches. The left was irrigated by division of paraconal and left circumflex branches.

Key words: *domestic pig, heart, coronary arteries.*

INTRODUCTION

Whereas the execution of allotransplantation is limited by the known conditions in humans, xenotransplantation has long been envisioned as an alternative (Johnson et al., 1999; Weaver et al., 1986).

Most investigators agree that pigs have the potential to be the prime candidates for organ donation. Pigs are plentiful, are quick to mature, breed well in captivity, have large litters, and have vital organs roughly comparable in size to those of humans.

Some authors suggested that at a time when transgenic pigs are being produced there is a need to look back at the fundamental anatomical features of this species (Crick et al., 1998).

Regarding cardiac anatomy there are only a few publications and, although it is a common saying that the pig's heart is similar to that of humans, there is a lack of comparative anatomy between the hearts in these two species (Kassab et al., 1994; Rodrigues et al,, 2005; Sahni et al., 2008).

To complement the data from the literature, we conducted a detailed study on the distribution of coronary arteries in the domestic pig.

MATERIALS AND METHODS

The research was conducted on 10 hearts from slaughtered animals. The animals had weights between 90 and 100 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, it was introduced the plastic substance for contrast (AGO) in the lumen of 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. The most representative pieces were photographed.

Identification and description was achieved using Nomina Anatomica Veterinaria -2005.

RESULTS AND DISCUSSIONS

The morphology of the right artery

This artery arises from the cranial part of the aortic bulb, right from the arterial pulmonary trunk. It is oriented towards the cranial side of the heart, being disguised at the ventral side of the right atrium.

On its way through the coronary groove issues, from the origin to the terminal, ventricular and arterial collaterals.
Ventricular collaterals, detached from the latero-ventral face of the artery starting from the origin, are represented in the following order by the next blood vessels:
The first branch, rather reduced, irrigates the right half of the pulmonary arterial cone (Fig. 2-2).
The next collateral is very well represented, having the biggest caliber among all the collaterals of the right coronary artery. This collateral, descends on the auricular face of the right ventricle, having a ventrocranial trajectory towards anterior border. It issues secondary branches on the trajectory, both towards the auricular side of the right ventricle and towards the cranial border of the heart. The branches issued towards the auricular face of the right ventricle are in a number of 4-5 and decrease in length towards the cranial border of the heart (Fig. 2-3).
The first two branches, longer than approximately 3-4 cm, and more sinuous, reach till near the paraconal groove. The next 3 collaterals, relatively smooth and shorter (ca. 1 cm), lean to the limit between the cranial border and the auricular face of the right ventricle.
The branches detached from the anterior margin of the main trunk and directed towards the cranial margin of the right ventricle are smaller and decrease progressively to the terminal part of the artery.
Through its branches distribution, this collateral of the right coronary artery provides the dominant irrigation of the right ventricle's auricular face. After the issuance of this collateral, the right coronary artery, gradually releases in the same direction 3-4 delicate branches that get lost in the superior border of the right ventricle, in the cranial part of the coronary groove.
The next well represented collateral, issued by the right coronary artery, detaches from the cranial border of the right ventricle. It descends until approximately the half of the superior face of the cranial border from the right ventricle.
On the atrial face of the heart, the right coronary artery issues in a craniocaudal direction, as a first collateral, an artery that splits after ca. 0.5 cm, each branch having a sinous and descending in the upper third of the cranial part of the atrial face from the right ventricle (Fig. 3).

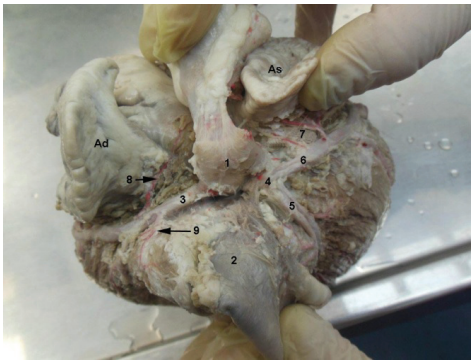

Fig. 1. The origin of the coronary arteries (original)
1-aorta; 2-pulmonary trunk; 3- right coronary artery; 4-left coronary artery; 5-the paraconal branch; 6- the circumflex branch 7- atrial colaterals of the circumflex branch; 8-atrial colaterals of the right coronary artery; 9-first collateral branch of right coronary artery; Ad(Ra)-Right atrium; As(La)-left atrium.

Fig. 2. The origin of the right coronary artery-dorsocranial view of the heart (original)
1-right coronary artery; 2- branch destined for the right half of the pulmonary arterial cone; 3-the most voluminous ventricular colateral of the right coronary arter; 4-atrial colateral of the right coronary artery; 5-right auricle; 6- aorta; 7-pulmonary trunk; 8-right ventricle; 9-ventricular branch of the right coronary artery.

Behind this collateral, the right coronary artery send, from the lateral face, 2-3 short and delicate ventricular branches which depletes in the upper border of the right ventricle, near the coronary groove.
The last ventricular collateral, well represented, issued by the right coronary artery on the atrial face of the heart, detaches at approximately 1 cm cranial from the origin of the subsinusal branch (Fig. 3). Through this collateral, the right coronary artery irrigates the upper half of the middle third of the atrial face of the right ventricle.
As atrial collaterals, the right coronary artery releases:
A first collateral, which is also the best represented, and which ramificates on the left face at the base of the right atrium till the interatrial septum (Fig. 1, 2) The next 2-3 collaterals approach the ventricular side of the right atrium at the cranial side of the heart.
The last 2-3 atrial collaterals, detached from the medial face of the coronary artery are delicate and short branches that address the base of the eccentric wall of the right atrium.
The terminal branches of the right coronary artery are represented in swine through the right interventricular branch or the subsinsual branch and the atrioventricular branch (the circumflex branch) (Fig. 4). The subsinusal branch, appears as a main terminal of the right coronary artery. Descends through the subsinusal groove having a descending trajectory, slightly oblique in a caudal direction. Terminally, the artery becomes delicate and penetrates the thickness of the myocardium at the level where the ventral extremity of the subsinusal groove unites with the atrial extremity of the paraconal groove. On the trajectory, the subsinusal branch issues from the cranial border 3-4 ventricular branches destined to the septal border on the atrial face of the right ventricle. From the caudal border of the subsinusal branch detach short and delicate arterial branches for the right border of the posterior wall of the left ventricle.
The atrioventricular branch (circumflex) of the right coronary artery presents at origin a lower caliber than the subsinusal branch (Fig. 4).

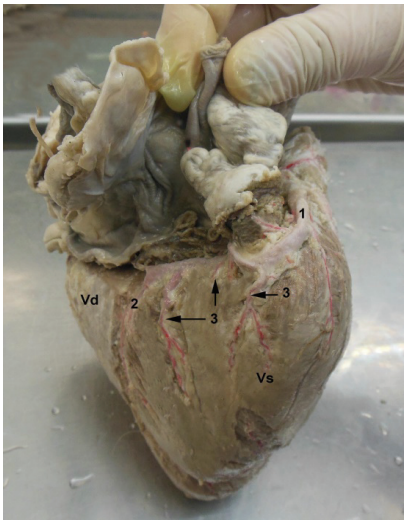

Fig. 3. The trajectory of the right coronary artery on the atrial face of the heart (original)
1-right coronary artery; 2- subsinusal branch; 3-ventricular colaterals of the right coronary artery on the atrial face; Vd(Rv)-right ventricle; Vs(Lv)-left ventricle

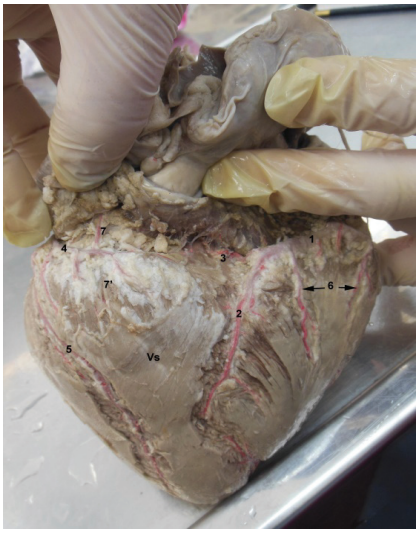

Fig. 4. The terminal branches of the right coronary artery (original)
1-the right coronary artery; 2- subsinusal branch; 3-right circumflex branch 4- left circumflex branch; 5-the most voluminous colateral of the left circumflex branch; 6- ventricular colaterals of the right coronary artery; 7,7'-atrial and ventricular branches of the left circumflex artery; Vs (Lv)-left ventricle

The main trunk oriented medially, ventral from the coronary sinus where it forks in a deep branch and a superficial one.
The deep branch reaches the upper third of the interventricular septum, and the superficial branch, shorter and more delicate, has a trajectory of 2-3 cm behind the coronary sinus. On this part, the superficial branch issues delicate atrial branches, that approach the ventral border of the terminal part of the left azygos vein.

The morphology of the left coronary artery

The left coronary artery detaches from the left side of the aortic bulb, passes by behind the arterial pulmonary trunk and after a very short trajectory (approximately 2-3 mm) it ends though the paraconal branch and the circumflex branch (Fig. 1, 5). At its origin the left coronary artery is disguised by the caudal margin of the pulmonary trunk and the left auricle.
The paraconal branch follows in a cranioventral way the direction of the homonymous groove. At the pig this groove it's characterized by a pronounced obliquity. It extends from the auricular face of the heart to the atrial face, intersecting the cranial border of the right at the limit between the middle third and it's inferior third. Terminally, the paraconal branch issues ramifications towards the distal extremity of the subsinusal groove, where they interpenetrate with the terminal branches of the subsinusal branch, from the right coronary artery, without anastomosing with these (Fig. 6).
On its trajectory, the paraconal branch issues collaterals detahced both from the cranial border and from the caudal border.
The first detached collateral from the cranial border of the paraconal branch has and ascending trajectory in a craniodorsal way and it ramificated in the posterior half of the left face at the arterial pulmonary cone level (Fig. 2).
The next two collaterals, having a horizontal orientation, detach from an approximately 3 cm distance and assure the irrigation of the parietal wall of the right ventricle in the middle third of the auricular face.

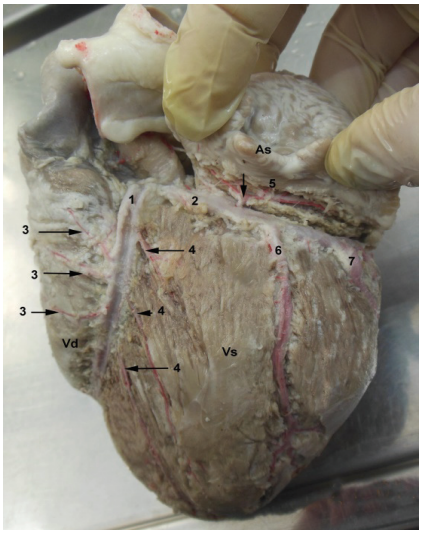

Fig. 5. The left coronary artery's terminals of the auricular face of the heart (original)
1-paraconal branch; 2- left circumflex branch; 3-right ventricular colaterals of the paraconal branch; 4-left ventricular colaterals of the paraconal branch; 5- the atrial branch of the left circumflex; 6,7-the main ventricular colaterals of the left circumflex branch; As(La)- left atrium; Vd(Rv)-right ventricle ; Vs(Lv)- left ventricle.

Distally from these, from the cranial border of the paraconal branch detach 2-3 collaterals that irrigate the distal third of the auricular face of the right ventricle in the part situated near the paraconal groove. At the level at which the paraconal groove intersects the cranial border of the right ventricle, the paraconal branch issues a ventricular branch that has an ascending trajectory and issues collaterals at the right and left from the main torso. This branch, through its distribution mode ensures the irrigation of the anterior wall of the right ventricle in its distal third (Fig. 6).
After the paraconal branch exceeds the anterior border of the heart, reaches on atrial face where it continues until the terminal extremity level of the subsinusal branch.
In this area it issues 2-3 delicate collaterals, with an ascending trajectory, that irrigates the anterior wall of the right ventricle towards the ventricle's tip and 3-4 collaterals with a descending trajectory. One of these is best represented and oriented towards the apex of the heart where it's ends with ramifications.

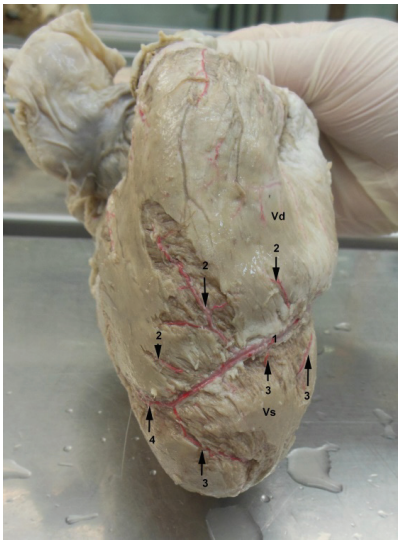

Fig. 6 The terminal part of the paraconal branch (original)
1-interventricular paraconal branch; 2- ascending branches (right ventricular) from the paraconal branch; 3- descending branches (left ventricular) from the paraconal branch; 4- the interlacing of the paraconal branch's terminals with the ones from the subsinusal; Vd(Rv)-right ventricle; Vs(Lv)-left ventricle

The first caudal collateral issues at approximately 2 cm from the paraconal branch's origin. It has an oblique orientation in the caudoventral direction and an average length of about 4 cm.

The next caudal collateral, longer than the last and with a doubled caliber at its origin it detaches at approximately 2 cm distally from the first caudal collateral. It has a caudoventral oblique trajectory reaching the caudal border of the heart, towards which it ends at about 3 cm in a cranial sense.

The strongest of all caudal collaterals of the paraconal branch detach at approximately 1.5 cm from the previous branch. It obliquely descends towards the caudal border of the heart which it touches at about 3 cm dorsally from the apex where it ends with ramifycations. Close to the terminal area (at approximately 3 cm from the caudal margin), it issues a strong apexial branch that lowers to the heart's apex where it ends bifurcated. From the cranial border, this collateral ensures the irrigation of the ventral half of the auricular part of the left ventricle.

Though these three collaterals, the paraconal branch dominantly irrigates the superior half of the auricular face of the left ventricle.

The last released branches from the caudal border towards the paraconal branch are relatively soft and finish the ventral third of the auricular face of the left ventricle and in the heart's apex area.

The cricumflex branch presents at its origin a similar caliber with the one from the paraconal branch. It's oriented caudally at the coronary groove level, passing in the end on the right face of the heart having the last ramifications oriented at the ventral face of the coronary sinus.

On its trajectory, the circumflex branch issues atrial ascending collaterals that are lost in the base part of the left atrium and descending ventricular collaterals that appear much better represented.

The ascending collaterals, released from the origin towards the terminal part, have the following trajectory:

The first ascending branch rises to the anterior border of the left atrium that it's approached in approximately the middle third of the part in which the atrium surrounds the posterior border of the ascending aorta.

The next collateral, detaches at about 1 cm caudally from the previous. The common trunk is very short (approximately 2 mm), after which it ends though a cranial branch and a caudal one (Fig. 1).

The cranial branch it's disposed at the base of the left atrium on its auricular face and it's oriented towards the base of the left auricle.

The caudal branch is turned to the caudal border of the heart through the coronary groove, proximal from the circumflex branch. It's masked at the ventral face of the left atrium. It issues branches that approach the ventral border of the left atrium from the coronary groove. On the right face of the heart, the circumflex branch releases 2-3 atrial collaterals that become shorter and softer towards the terminal part of the circumflex branch. These collaterals approach the atrial face of the right ventricle from its ventral border, some reaching the ventral face of the terminal part of the left azygos vein.

Concerning the distribution of the descending ventricular collaterals, we have the following

situation. The first detached at approximately 3.5-4 cm from the origin of the circumflex branch. It is better represented both from a caliber point of view and as a distribution territory. Its origin diameter reaches ca. 2 mm and in a distal direction it reaches till the limit between the middle third and the inferior third of the posterior border of the heart. The artery's trajectory is oblique and in a caudoventral sense (Fig. 5).

On the trajectory, it issues both anterior and posterior 3-4 delicate branches in each side that penetrate the superficial part of the myocardium. Apart from these, there are also deep myocardial branches, detached from the deep face of the main torso. These are distributed in the thickness of the posterior wall of the left ventricle.

At approximately the half of the posterior border of the heart level, the first ventricular collateral of the circumflex branch ends forked in a sharp angle. The two terminals are equally sensitive and descend in a superficial scheme reaching about 3 cm proximal from the heart's apex.

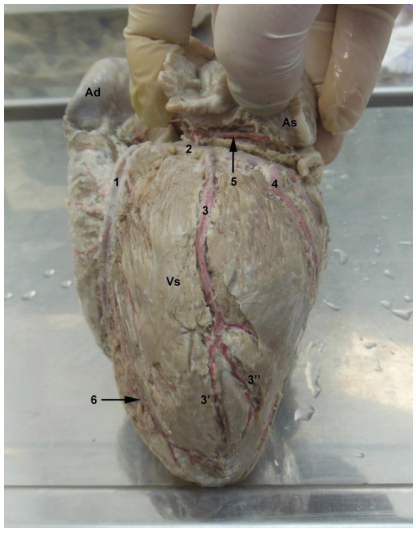

Fig. 7. The trajectory of the left circumflex branch on the caudal border of the left ventricle (original) 1-paraconal branch; 2-circumflex branch; 3-intermediary ventricular branch; 3', 3''- terminals of the intermediary; 4- the branch destined ofr the right face (atrial) 5- atrial branch from the left circumflex branch; 6- left ventricular colateral of the paraconal branch; Ad(Ra)- right atrium; As(La)- left atrium; Vs(Lv)- left ventricle

The following well represented collateral detached from the circumflex branch's ventral border, has the biggest caliber at its origin, disposing of a transversal diameter of about 3 mm at its origin.

This collateral detaches at the level of the caudal border of the heart, after which it has an oblique trajectory pronounced towards the right face of the heart. The terminal part of this collateral reached the heart's apex (Fig. 4).

On its trajectory this collateral releases superficial branches that irrigate the left ventricle's wall on its atrial face, especially in the caudoventral half of this face.

The caudal branches, detached from the second collateral of the circumflex branch it's oriented towards the caudal border of the heart and ensures the irrigation of the myocardum at the level of the caudal border of the left ventricle.

La the level of the right face of the heart, the circumflex branch issues 4-5 ventricular branches, that decrease progressively towards the terminal part of the circumflex branch. These branches descend in the left ventricle's wall approached by the superior middle third of the atrial face.

CONCLUSIONS

Right coronary artery is long and its terminal branches are subsinusal branch and right circumflex branch. Artery supplies five main branches to the wall of right ventricle. Atrial collaterals are represented by a main branch, issued on the left side of the right atrium and a number of smaller branches relatively equal, further detached from the main trunk.

Left coronary artery is short. Left ventricular wall is irrigated by its terminal branches.

While subsinusal branch show collateral branches designed especially to right wall of interventricular septum, paraconal branch presents both right and left parietal ventricular collaterals.

Although is constant, intermediate caudal branch was not always the best represented.

With the naked eye were not observed anastomoses between the branches of the coronary arteries.

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