

## THE CORONARY ARTERIES OF THE GARDEN DORMOUSE (*ELIOMYS QUERCINUS* L., 1766)

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**ABSTRACT** – The arrangement of the coronary arteries was studied in 18 Garden dormice (4♂♂, 14♀♀). Most of them (n=17) were examined using a corrosion-cast technique, while the remaining specimen was studied histologically. In the Garden dormouse the heart shows no interventricular grooves, and both the right and left coronary arteries become intramyocardial shortly after their origin from the aorta. The right coronary artery has two principal branches: the right circumflex branch and the dorsal interventricular branch. The conal branch also originates from the main trunk of the right coronary artery. The main branches of the left coronary artery are the left circumflex branch and one or two dorsal ventricular branches. When two dorsal ventricular branches exist, one of them often behaves as an obtuse marginal branch, running along the proximal half of the obtuse margin of the heart; thereafter the vessel turns towards the dorsal wall of the left ventricle. The ventral interventricular branch is sometimes absent. When present, it always rises from the left coronary artery and does not reach the apex of the heart. The ventricular septum is principally supplied by a well-developed septal artery arising from the left coronary artery; thus, the Garden dormouse exhibits a left septal pattern. A less important vascularization of the septum is established through thinner penetrating vessels originating from the right and left coronary arteries.

**Key words:** Coronary arteries, Heart, Rodentia, *Eliomys quercinus*.

**RIASSUNTO** – *Le arterie coronarie del Topo quercino (Eliomys quercinus L., 1766)* – Sono stati studiati l'origine ed il decorso delle arterie coronarie in 18 topi quercini (4♂♂, 14♀♀). Diciassette animali sono stati esaminati con una tecnica di iniezione nell'albero coronarico di una resina con successiva corrosione dei tessuti molli. L'altro esemplare è stato studiato istologicamente. Il cuore del quercino non ha solchi interventricolari e le arterie coronarie destra e sinistra diventano intramiocardiche immediatamente dopo l'origine dall'aorta. Nell'arteria coronaria destra si distinguono due rami principali: il ramo circonflesso destro ed il ramo interventricolare dorsale. Anche il ramo conale origina dal tronco principale dell'arteria coronaria destra. Nell'arteria coronaria sinistra si distinguono: il ramo circonflesso sinistro ed uno o due rami ventricolari dorsali. Quando esistono due rami ventricolari dorsali, uno di loro spesso si comporta come un ramo marginale ottuso, correndo, nella prima parte, lungo la meta prossimale del margine ottuso cardiaco e proseguendo poi sulla faccia dorsale del ventricolo sinistro. Anche il ramo interventricolare ventrale, che non è sempre presente, si origina dall'arteria coronaria sinistra e non raggiunge mai l'apice cardiaco. Il setto ventricolare è principalmente irrorato da una arteria settale bene sviluppata che si origina dall'arteria coronaria

sinistra. In minor misura, il setto ventricolare è vascularizzato da vasi penetranti più sottili, che nascono dalle arterie coronarie destra e sinistra.

Parole chiave: Arterie coronarie, Cuore, Rodentia, *Eliomys quercinus*.

## INTRODUCTION

The data published on the blood supply to the heart in Rodents cover a limited number of species (see Duran, 1990, for an extensive review of the literature).

Knowledge of this vascularization in Myoxids is scarce. Banchi (1904) mentioned the existence of two coronary arteries, right and left, in the Fat dormouse (*Myoxus glis*). On the other hand, Duran et al. (1992) gave brief accounts of the blood supply to the ventricular septum in the Garden dormouse.

The lack of more precise information on the vascularization of the heart in Myoxids, induced us to undertake a study of the coronary artery pattern of the Garden dormouse. The aim of the present report is to describe the main features of this pattern.

## MATERIAL AND METHODS

The origin and course of the coronary arteries was studied in 18 Garden dormice (4 ♂♂, 14 ♀♀) collected with live traps in Spain and Andorra. Most of them (n=17) were examined using a corrosion-cast technique. The remaining specimen was studied histologically. All the animals were handled in compliance with international policies for animal care and welfare, and were sacrificed by overdosing with chloroform. In every case, the ventral aspect of the heart was exposed by means of a thoracotomy at the level of the fifth intercostal space.

**Corrosion-cast technique.** A vinyl resin (Rhodopas® AX 85/15) in a 20% ketone solution was injected via a cannula placed in the ventral aorta through the apex of the left ventricle. Internal casts of the left ventricle and arterial vessels were obtained by macerating the specimens in a 20% hydrochloric acid bath.

**Histology.** The heart was perfused with heparinized 0.9% physiological saline, fixed in 10% neutral formalin buffered with magnesium carbonate, and embedded in paraffin. Transverse sections serially cut at 10 µm for light microscopy were stained with Mallory's trichroine stain.

## RESULTS

The coronary artery pattern of the Garden dormouse is characterized by the existence of two well-developed coronary arteries, the right and left (Fig. 1), originating from the right and left aortic sinuses respectively. The coronary ostia are usually located in the center of the aortic sinuses, close to the level of the free margin of the aortic valve cusps. The heart of the Garden dormouse shows no interventricular grooves, and the coronary arteries become intramyocardial shortly after their origin from the aorta (Fig. 2).

The right coronary artery (Fig. 1) basically supplies the right side of the heart. The main coronary trunk generally runs parallel to the right atrioventricular groove, but in some cases the vessel gradually diverges from it. Before reaching

the acute margin of the heart, this trunk gives off a conal branch and one or two atrial branches supplying the right atrium as well as much of the atrial septum.

Moreover, the main trunk sends one to three branches to the ventral wall of the right ventricle. In most cases, the main trunk also gives rise to a more or less developed acute marginal branch (Fig. 1), which follows a somewhat variable course towards the apex of the heart.

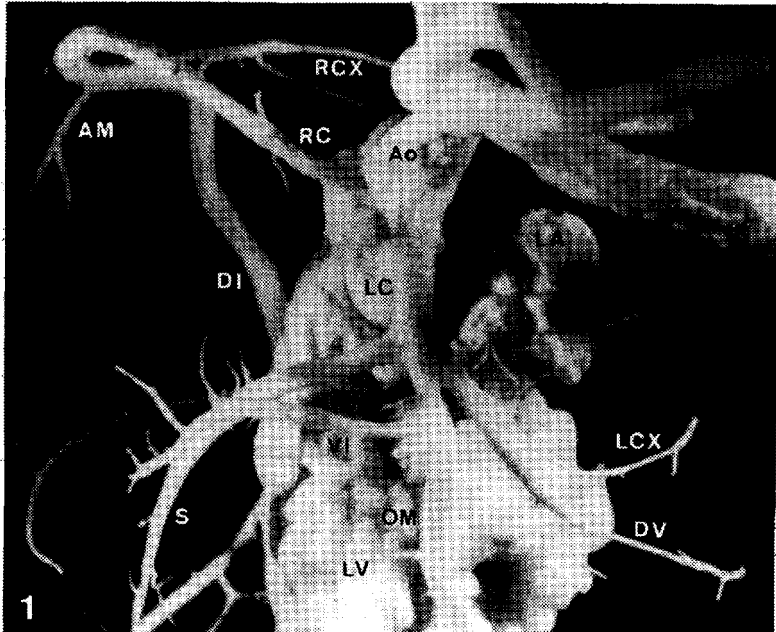


Fig. 1 – Internal cast of the left ventricle, aorta, and coronary arteries of *Eliomys quercinus*. Ao: aorta; AM: acute marginal branch; DI: dorsal interventricular branch; DV: dorsal ventricular branch; LA: left atrium; LC: left coronary artery main trunk; LCX: left circumflex branch; LV: left ventricle; OM: obtuse marginal branch; RC: right coronary artery main trunk; RCX: right circumflex branch; S: septal artery; VI: ventral interventricular branch.

Having reached the acute margin of the heart, the main coronary trunk gives off a vessel which runs more or less parallel to the atrioventricular sulcus, as a right circumflex branch (Fig. 1), supplying branches to the dorsal wall of the right ventricle. The right circumflex branch usually reaches the dorsal interventricular boundary. In some cases, however, the vessel passes this limit, extending towards the left ventricle. Thereafter, the main trunk crosses the dorsal wall of the right ventricle obliquely, and before reaching the dorsal interventricular limit or just at this site, the vessel turns towards the apex of the heart as a dorsal interventricular branch (Fig. 1). Along its course throughout the dorsal wall of the left ventricle, the right coronary trunk sends one to four branches to the acute margin of the heart and two or three branches to the dorsal interventricular boundary, some of which may pass this limit, supplying the dorsal wall of the left ventricle.

The left coronary artery principally supplies the left side of the heart. The main trunk of the left coronary artery (Fig. 1) first passes dorsally round the pulmonary

trunk and then becomes intramyocardial (Fig. 2). Before reaching the obtuse margin of the heart, the main trunk sends an atrial branch which supplies the left atrium as well as a portion of the atrial septum.



Fig. 2 – Transverse section of the heart of *Eliomys quercinus* at the level of the aortic valve (**A**). Note that the right (R) and left (L) coronary arteries show an intramyocardial course. x16, Mallory's trichrome.

The branching of the left main coronary trunk is somewhat variable. Usually, it divides in fan-like fashion at the level of the obtuse margin (Fig. 1). One or two of the resulting vessels are well-developed dorsal ventricular branches (Figs. 1, 3), which spread over the dorsal and ventral walls of the left ventricle. When two dorsal ventricular branches exist, one of them can behave as an obtuse marginal branch, running along the proximal half of the obtuse margin (Fig. 1); thereafter, the vessel turns towards the dorsal wall of the left ventricle. Another of the resulting branches generally runs more or less parallel to the left atrioventricular sulcus as a left circumflex branch (Fig. 1). In most cases, this branch terminates a short distance from the dorsal interventricular boundary. However, it may pass this limit, supplying branches to the dorsal wall of the right ventricle. A ventral interventricular branch often exists as well (Figs. 1, 3). It arises either from the point at which the main coronary trunk divides in a fan-like fashion or from the obtuse marginal branch (Fig. 1), and runs along the ventral interventricular limit. However, the vessel rarely extends further than the proximal third of this limit. When present, the ventral interventricular branch supplies the proximal third of the ventral wall of the left ventricle as well as the infundibular portion of the ventricle.

The ventricular septum is supplied in two ways, namely by a well-developed septal branch, usually called the septal artery (Figs. 1, 3), and by thinner penetrating vessels mainly originating from the right coronary artery.

In all of the specimens examined, the septal artery originated from the left coronary artery, either from the main coronary trunk (17 cases; Fig. 1) or from the ventral interventricular branch (1 case). The septal artery arises on the right and crosses the infundibular portion of the septum transversally or obliquely to reach the right side. Thereafter, the vessel turns towards the apex of the heart, running very close to the right ventricle lumen (Fig. 3), and generally extends no further

than the proximal two thirds of the septum. The main septal trunk gives off a variable number of perpendicular and oblique branches supplying the dorsal and ventral septum surfaces. Some of these ventral branches can even irrigate the ventral wall of the left ventricle.

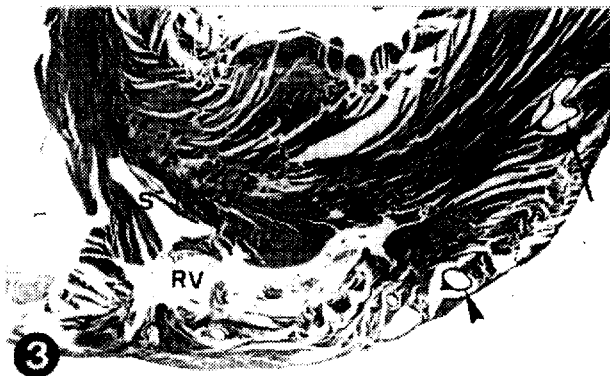


Fig. 3 – Transverse section of the heart of *Eliomys quercinus*. The septal artery (S) runs very close to the lumen of the right ventricle (RV). Arrow: dorsal ventricular branch of the left coronary artery; Arrowhead: ventral interventricular branch. x16, Mallory's trichrome.

The most important contribution to the vascularization of the ventricular septum through penetrating vessels is due to the dorsal interventricular branch. At different levels of its course towards the apex of the heart, this vessel gives off a variable number of branches which penetrate more or less deeply into the septum (Fig. 4). Sometimes, the distal segment of the dorsal interventricular branch gradually enters the septum, reaching its middle part, and sends out short penetrating vessels. Dorsal parietal branches of the right coronary artery can also slightly penetrate the septum. Moreover, penetrating vessels often arise from the circumflex, dorsal ventricular, and ventral interventricular branches of the left coronary artery.

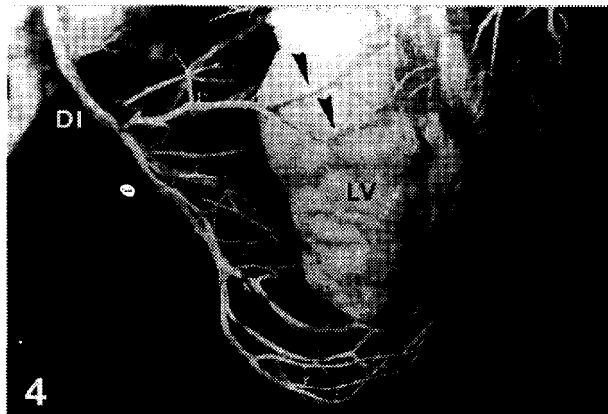


Fig. 4 – Internal cast of the left ventricle and coronary arteries of *Eliomys quercinus*. Vessels (arrowheads) originating from the dorsal interventricular branch (DI) penetrate the ventricular septum.

## DISCUSSION

The Garden dormouse shows intramyocardial coronary arteries. Our observations indicate that, in this species, the principal branches of the right coronary artery are the right circumflex branch and the dorsal interventricular branch. The conal branch also originates from the right coronary artery main trunk. The main branches of the left coronary artery are the left circumflex branch and one or two dorsal ventricular branches. When two dorsal ventricular branches exist, one of them often behaves as an obtuse marginal branch, running along the proximal half of the obtuse margin of the heart; thereafter the vessel turns towards the dorsal wall of the left ventricle. The ventral interventricular branch is sometimes lacking. When present, it always takes its origin from the left coronary artery and does not reach the apex of the heart. The ventricular septum is principally supplied by a septal artery originating from the left coronary artery.

In the Garden dormouse the dorsal interventricular branch always arises from the right coronary artery. It should therefore be stated that this species exhibits a right dominant coronary artery system, according to the criteria usually applied in anatomical (Lerer & Edwards, 1981) and angiographic (Higgins & Wexler, 1975; Hutchins et al., 1978) studies carried out on human subjects. However, we believe that such an interpretation would not be accurate, since the area supplied by the dorsal interventricular branch in the Garden dormouse is far less significant than that irrigated by the posterior descending artery and the posterolateral branches in man. In fact, if we do not consider the area supplied by the septal artery, the Garden dormouse shows a fairly balanced coronary artery pattern. This seems not to be the case in the Fat dormouse. Banchi (1904) examined the coronary arteries in two specimens of this species, and reported briefly that, in both cases, the right coronary artery was far less developed than the left coronary artery. Moreover, he mentioned that in one of these specimens, the left Circumflex branch originated from a separate ostium in the aorta.

To our knowledge, the blood supply to the heart in Rodents with intramyocardial coronary arteries has currently been studied in detail in only three species; namely, the Syrian hamster (*Mesocricetus auratus*), the laboratory Rat (*Rattus norvegicus* var. *albinus*), and the Guinea pig (*Cavia porcellus*).

The main features of the coronary artery pattern of the Garden dormouse are very similar to those reported by Sans-Coma et al. (1993) in the Syrian hamster.

The sole difference between these two species concerns the obtuse marginal branch. In the Syrian hamster, this vessel is always well-developed in size and branching, and runs down to the apex of the heart along the whole obtuse margin. In contrast, a true obtuse marginal branch does not exist in the Garden dormouse.

Major differences seem to exist between the arrangement of the coronary arteries in the Garden dormouse and those reported in the Rat and Guinea pig. In the Rat there is no distinct dorsal interventricular branch (Halpern, 1957; Ahmed et al., 1978), whereas this vessel originates from the left circumflex branch in the Guinea pig (Ahmed et al., 1978; Vicentini et al., 1991). In the Garden dormouse, as in the Syrian hamster (Sans-Coma et al., 1993), the dorsal interventricular branch always arises from the right coronary artery. On the other hand, it is

basically accepted that in both the Rat and Guinea pig, the left coronary artery has two principal branches; the left circumflex branch and the ventral interventricular branch. This is not the case in the Garden dormouse, nor in the Syrian hamster (Sans-Coma et al., 1993), in which the interventricular branch is very often less developed or even absent.

The blood supply to the ventricular septum mainly through a well-developed septal artery, as found in the Garden dormouse, or through two septal arteries, as occasionally observed in other Rodent species (Duran et al., 1992), seems to be a feature closely related to the intramyocardial course of the coronary arteries (Durán et al., 1991; Duran et al., 1992). In Mammals, including Rodents, with subepicardial coronary arteries the vascularization of the septum is usually through numerous perforating vessels originating from the right and left coronary artery branches. In such cases, a distinct septal artery is lacking (Duran et al., 1992). As already stated by Sans-Coma et al. (1993), the importance of the septal arteries in hearts with intramyocardial coronary arteries should be emphasized because they supply the greater part of the septum, a structure which plays a remarkable role in the systolic performance of the left ventricle, and includes a considerable portion of the heart's conducting system. In Rodents with intramyocardial coronary arteries, three septal coronary artery patterns have been established, according to the number and origin of the septal arteries; namely, the right, the left, and the right-left septal patterns (Duran et al., 1992; Sans-Coma et al., 1993). The right and left septal patterns are characterized by the existence of a single septal artery originating from the right and left coronary arteries, respectively. In the right-left septal pattern there are two septal arteries, one arising from the right, the other from the left coronary artery. According to this classification, all of the 18 Garden dormice studied showed a left septal pattern. This differs from observations in the Fat dormouse; the two specimens examined by Banchi (1904) exhibited a right septal pattern. In this context, it is interesting that the left septal pattern has been found to be the most common in Arvicolid and Cricetid representatives, whereas the right septal pattern is by far the most frequent in Murids (Duran et al., 1992).

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## REFERENCES

- AHMED, S.H., RAKHAWY, M.T., ABDALLA, A. & ASSAAD, I. 1978. The comparative anatomy of the blood supply of cardiac ventricles in the albino rat and guinea pig. *J. Anat.*, 126: 51-57.
- BANCHI, A. 1904. Morfologia delle arteriae coronariae cordis. *Arch. Ital. Anat. Embriol.*, 3: 87-164.
- DURÁN, A.C. 1990. Estudio de las arterias coronarias en Mamíferos de los órdenes Insectívora y Rodentia. Doctoral Thesis. Faculty of Science, University of Malaga.
- DURAN, A.C., SANS-COMA, V., CARDO, M. & ARQUÉ, J.M. 1991. The blood supply to the interventricular septum in Soricoidea (Mammalia). *Zool. Anz.*, 227: 279-285.

- DURÁN, A.C., SANS-COMA, V., ARQUÉ J.M., CARDO, M., FERNÁNDEZ, B. & FRANCO, D. 1992. Blood supply to the interventricular septum of the heart in rodents with intramyocardial coronary arteries. *Acta. Zool. (Stockholm)*, 73: 223-229.
- HALPERN, M.H. 1957. The dual blood supply of the rat heart. *Am. J. Anat.*, 101: 1-16.
- HIGGINS, C.B. & WEXLER, L. 1975. Reversal dominance of the coronary arterial system in isolated aortic stenosis and bicuspid aortic valve. *Circulation*, 52: 292-296.
- HUTCHINS, G.M., NAZARIAN, I.H. & BULKLEY, B.H. 1978. Association of left dominant coronary arterial system with congenital bicuspid aortic valve. *Am. J. Cardiol.*, 42: 57-59.
- LERER, P.K. & EDWARDS, W.D. 1981. Coronary arterial anatomy in bicuspid aortic valve. Necropsy study of 100 hearts. *Br. Heart J.*, 45: 142-147.
- SANS-COMA, V., ARQUÉ, J.M., DURÁN, A.C., CARDO, M., FERNÁNDEZ, B. & FRANCO, D. 1993. The coronary arteries of the Syrian hamster, *Mesocricetus auratus* (Waterhouse, 1839). *Ann. Anat.*, 175: 53-57.
- VICENTINI, C.A., ORSI, A.M. & MELLO DIAS, S. 1991. Observations anatomiques sur la vascularisation artérielle coronarienne chez le cobaye (*Cavia porcellus* L.). *Anat. Anz.*, 172:209-212.