

THE INCIDENCE AND VARIATION OF ATRIAL VEINS IN THE HEART OF DOGS¹

MARIE C. COLE, L. J. A. DiDIO and R. A. YEASTING, Department of Anatomy, Medical College of Ohio at Toledo, C. S. 10008, Toledo, OH 43699

Abstract. The atrial veins of 40 normal adult dogs were injected, identified, dissected, drawn, and photographed. Their origin, distribution, termination, and arterial relationship were studied on the surface of each atrium. They appeared most frequently on the left atrium, especially in the dorsal lateral third (85% of the cases), and ventral intermediate third (32.5%). Whereas the left dorsal medial third exhibited veins in 25% of the cases, none were present in the ventral medial third. The percentage of cases varied in the right atrium from 5% (ventral intermediate third) to zero (dorsal medial third). In most cases, each vein accompanied an atrial artery. Exceptions were 3 cases where 2 veins were satellites of an artery and 16 cases where the veins were isolated. Each vein was named after the third in which it terminated.

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The scarcity of numerical data on the presence of the canine cardiac veins in general, and the atrial veins in particular, as well as the increasing importance of detailed information for possible human application owing to new experimental developments in cardiac shunts, led us to initiate a study of the venous system of the heart of the dog. The present paper deals with the frequency and variations of the veins that appear on the external aspect of the canine cardiac atria.

To the best of our knowledge, the anatomy of blood drainage in the atria of the canine heart has been studied by: Zimmerl (1900), Kazzaz and Shanklin (1950), Bruni and Zimmerl (1951), Butterworth (1954), Barone and Malavieille (1957), Christensen and Campeti (1959), Miller, Christensen and Evans (1968), and Getty (1975).

MATERIALS AND METHODS

Forty adult mongrel dogs (26 males and 14 females) were used in this investigation. Their weights ranged from 13.2 kg to 27.6 kg (average 18.3 kg). Soon after sacrificing the dogs with sodium pentobarbital, the thorax was opened and the heart was removed. After rinsing the cardiac chambers with cold water and 10% saline, the coronary arteries were cannulated and injected with colored gelatin by means of a

syringe (red into the right coronary and blue in the left coronary artery). In most cases, the veins were injected by retrograde flow. The great cardiac vein was cannulated at its junction with the coronary sinus, and injected with blue gelatin. Each injected heart was fixed and preserved in a 10% solution of formaldehyde.

The epicardium was carefully removed from the heart. The coronary arteries, along with their branches, and the cardiac veins were dissected and drawings were made of each heart. Photographs were taken of the most interesting specimens.

RESULTS

To facilitate the presentation of our results, the heart was divided into an atrial hemisphere and a ventricular hemisphere. The atrial hemisphere was subdivided into quadrants by a frontal and a sagittal line. The sagittal line crossed the aorta between the orifices of the coronary arteries, joining the ventral and dorsal aspects of the heart. The frontal line was drawn perpendicular to the sagittal line and tangential to the dorsal aspect of the aorta, uniting the right and left contours of the heart. The quadrants were named right ventral and right dorsal, left ventral and left dorsal. Each quadrant was divided into thirds (medial, intermediate, and lateral) (fig. 1).

The atrial veins were named according to the particular third of each quadrant in which they terminated. When a sat-

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ellite of an atrial artery, the vein in question was named after the artery. Of the 40 hearts studied, a total of 101 atrial veins was found, the average being 2.5 veins per heart.

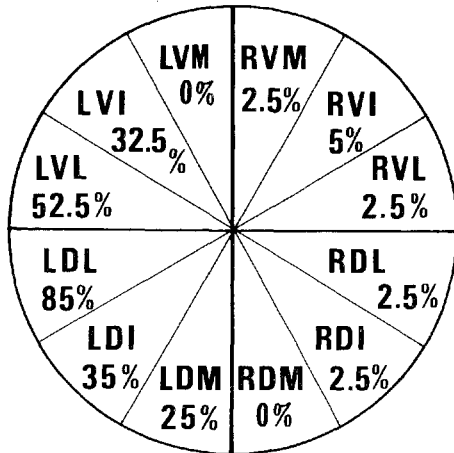


FIGURE 1. Diagram of the cranial view of the canine heart to show the atrial surface divided into quadrants and each quadrant subdivided into thirds. In each third are indicated the initials of the name of the area (see text) and the percentage of atrial veins (obtained from the number of cases in which they were observed out of 40 cases studied). RVM and LVM=right and left ventral medial thirds, respectively; RVI and LVI=right and left ventral intermediate; RVL and LVL=right and left ventral lateral; RDL and LDL=right and left dorsal lateral; RDI and LDI=right and left dorsal intermediate; RDM and LDM=right and left dorsal medial.

The incidence of the atrial veins in each third of the quadrants of the dog heart as indicated in figures 1 and 2 is as follows:

- (1) The right ventral medial atrial vein appeared in one heart out of 40 ($2.5\% \pm 2.5$). This vein accompanied the homonymous artery.
- (2) The right ventral intermediate atrial vein appeared in 2 hearts out of 40 ($5\% \pm 4.9$). It accompanied the homonymous artery.
- (3) The right ventral lateral atrial vein appeared in one heart out of 40 ($2.5\% \pm 2.5$). It accompanied the homonymous artery.
- (4) The right dorsal lateral atrial

- vein appeared in one heart out of 40 ($2.5\% \pm 2.5$). It accompanied the homonymous artery.
- (5) The right dorsal intermediate atrial vein appeared in one heart out of 40 ($2.5\% \pm 2.5$). It accompanied the homonymous artery.
- (6) No vein was found in the right dorsal medial region of the 40 hearts.
- (7) The left dorsal medial atrial vein appeared in 10 hearts out of 40 ($25\% \pm 6.8$). This vein accompanied the homonymous artery in 9 hearts out of 40 ($22.5\% \pm 7.0$). In one heart out of 40, there were 2 veins accompanying one artery ($2.5\% \pm 2.5$).
- (8) The left dorsal intermediate atrial vein appeared in 14 hearts out of 40 ($35\% \pm 7.5$). In 6 of our 40 hearts ($15\% \pm 5.7$), it accompanied the homonymous artery. In one heart out of 40 ($2.5\% \pm 2.5$), there were 2 veins accompanying one artery. In 7 hearts out of 40 ($17.5\% \pm 6.0$), this vein did not accompany any arteries.
- (9) The left dorsal lateral atrial vein appeared in 34 hearts out of 40 ($85\% \pm 5.7$). In 29 hearts out of 40 ($72.5\% \pm 7.1$), it accompanied the homonymous artery. In one heart out of 40 ($2.5\% \pm 2.5$), 2 veins accompanied one artery. In 4 hearts out of 40 ($10\% \pm 4.7$), it did not accompany any arteries.
- (10) The left ventral lateral atrial vein appeared in 21 hearts out of 40 ($52.5\% \pm 7.9$). In 16 hearts out of 40 ($25\% \pm 6.9$), it accompanied the homonymous artery. In 5 hearts out of 40 ($12.5\% \pm 5.2$), it did not accompany any arteries.
- (11) The left ventral intermediate atrial vein appeared in 13 hearts out of 40 ($32.5\% \pm 7.41$). It accompanied the homonymous artery.
- (12) No vein was found in the left ventral medial region of the 40 hearts.

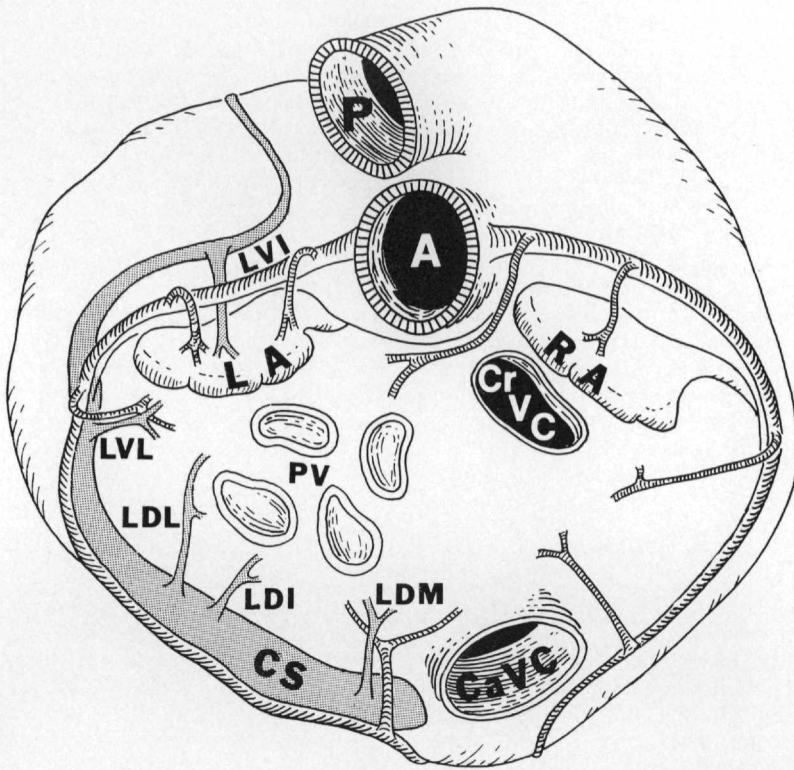


FIGURE 2. Diagram of the cranial aspect of the dog heart (Obs. 100, male, 18 k, mongrel). Auricles are reflected and distances enlarged to better illustrate the vessels. Atrial veins are only on the left side, 3 being satellites of atrial arteries and 2 single. Going clockwise: LDM=left dorsal medial vein, tributary of the coronary sinus (CS), present in 25% of the cases and accompanying the homonymous artery; LDI=left dorsal intermediate vein, single, present in 35% of the cases; LDL=left dorsal lateral vein (oblique vein of the left atrium), single, present in 85% of the cases; LVL=left ventral lateral vein, satellite of the artery, present in 52.5% of the cases; LVI=left ventral intermediate vein, accompanying the artery, present in 32.5% of the cases. P=pulmonary artery, A=aorta, RA=right auricle, LA=left auricle, CrVC=cranial vena cava, CaVC=caudal vena cava, PV=pulmonary veins.

The incidence of atrial veins was higher in the left cardiac atrium than in the right. The highest incidences of atrial veins occurred in the left dorsal lateral third (85%) and in the left ventral lateral third (52.5%). No atrial vein was found in the right dorsal medial third nor in the left ventral medial third. Each atrial vein accompanied an atrial artery in all but 2 areas of the heart.

Two veins accompanied an atrial artery (one case out of 40, or 2.5%) in the left dorsal medial third (2.5%), in the left dorsal intermediate third (2.5%), and in the left dorsal lateral third (2.5%). Veins that did not accompany any arteries were found only in the following areas: left ventral lateral third (5 cases

or 12.5%); left dorsal lateral third (4 cases or 10%); and left dorsal intermediate third (7 cases or 17.5%).

DISCUSSION

The atrial veins of the canine heart have received scant attention in both scientific papers and textbooks, which is most likely a reflection of their assumed lack of importance. According to Barone and Malavielle (1957), the monograph on the comparative anatomy of the cardiac vessels in domestic animals by Zimmerl (1900) went practically unnoticed. Bruni and Zimmerl (1951) mentioned only the oblique vein of the left atrium; Christensen and Campeti (1959) referred to "small and numerous atrial veins" in the heart

of the dog. Later, Miller *et al* (1968) indicated them as "small twigs" beside the oblique vein, and Getty (1975), described the oblique vein and stated that the vena cordis magna receives tributaries from the left atrium and that the vena cordis parva receives small vessels from the right atrium. At the most, atrial veins have simply been indicated when descriptions of the major cardiac veins were provided. The morphologic value of atrial veins in the heart and the recent development of surgical techniques in human hearts is requiring new and detailed study of the cardiac blood supply in mammals. Physiological investigations by Katz, Jochim, and Weinstein (1938), Beck and Mako (1941) and Gregg and Shipley (1947) have demonstrated the influence exerted by drainage on cardiac blood circulation and the role that atrial veins may play in experimental conditions, the importance of detailed knowledge has become apparent.

On the basis of our observations, we agree with Christensen and Campeti (1959) that the atrial veins are small and numerous; nonetheless it has been possible to trace and name them. Tracing was made easier through arterial and venous injection of colored gelatin, especially when the veins accompanied arteries, which occurred much more frequently than the incidence of single veins. The location, in one of the 12 thirds of the atrial contour, of the termination of each vein in the major cardiac vein provided the basis for the nomenclature. We followed Kazzaz and Shanklin (1950) in naming the veins after the corresponding arteries when both were associated. The nomenclature of human anatomy is not applicable, in this case, to animals, as stated by Barone and Malavieille (1957), owing to the different thoracic morphology and orientation of the heart in quadruped mammals and in man. Since we found veins unassociated with arteries (e.g., in the ventral lateral, dorsal lateral, and dorsal intermediate thirds of the left atrium), the termination of the end of the atrial vein was preferred for nomenclature purposes because it applied to all cases, including the arteries, and to human hearts as well (DiDio and Wakefield 1972).

Our study was restricted to the superficial atrial veins, which are visible without dissection on the epicardial aspect of the atria and responsible for draining the blood from the atrial wall. It excluded, therefore, cardio-aortic, cardiopulmonary, and extracardiac veins, but focused on the superficial veins which, according to Gregg and Shipley (1947), "appear to play the dominant role in draining the coronary vascular bed."

The absence of numerical data on the incidence of atrial veins prompted us to determine the percentage of their presence in the atria after dividing each into thirds. These results allowed us to indicate that the atrial veins are more frequently found in the left atrium than in the right, thus confirming Christensen and Campeti's (1959) statement.

In the left atrium, atrial veins were observed not only in the ventral medial third; but in the other thirds, the percentages varied from 25% of the cases (10/40 hearts) in the dorsal medial third at the level of the coronary sinus, up to 85% of the cases (34/40 hearts) in the dorsal lateral third, where the oblique vein of the left atrium is usually seen, confirming Getty's (1975) description. Our findings did not corroborate Barone and Malavieille's view (1957) that this vein in the dog is often missing. The results of our observations also differed substantially from those of Butterworth (1954), since the high incidence of cardiac veins found in our dogs did not confirm his observation that "with the exception of the fairly constant vena obliqua atri sinistri there are no large calibre veins draining the left atrium." This discrepancy may have resulted from the fact that we may have taken into account veins that were insignificant in diameter for Butterworth.

In the right atrium, the veins are much less frequent since in our series they appeared in 5% of the cases (2/40 hearts) in the right ventral intermediate third, in 2.5% of the cases (1/40 hearts) in the other thirds, except in the right dorsal medial third (in the dorsal wall, to the right of the interatrial septum), where they were not found. Atrial veins were found in almost all areas of the atria. In fact, only the left ventral medial and the

right dorsal medial thirds did not present an atrial vein.

As expected, the areas that had the highest incidence of veins were in the left atrium. In view of our results, we can not totally agree with Barone and Malavieille (1957), when they state that the "atrial tributaries of the horizontal segment of the vena cardiaca magna are small and only the left principal atrial vein, traceable under the left auricle, deserved mentioning". We found that 3 more veins appear in a significant number of cases: left ventral lateral (2 cases out of 40), left dorsal intermediate (14 cases out of 40), and left ventral intermediate (13 cases out of 40).

The relationship between atrial veins and arteries was considered by Barone and Malavieille (1957), who reported that often there were 2 veins for each artery, whereas Getty (1975) simply stated that in most cases the veins accompanied the arteries. Our observations were consistent with the fact that atrial veins, for the most part, are satellites of arteries; however, only in 3 cases were there 2 veins adjacent to an artery and in several instances the veins did not accompany any artery (7 cases in the left dorsal intermediate third, 5 cases in the left ventral lateral, third and 4 cases in the left dorsal lateral third).

Our observations have given statistical support to the view that atrial veins are more frequent in the left than in the right atrium and, at the same time, indicated that their number and diameter are more conspicuous than formerly believed. The veins are not always satellites of the arteries (thus requiring special

names), and the location of the termination of the atrial veins is a simple and convenient criterion for their nomenclature.

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