

# Persistent Left Cranial Vena Cava in Dogs: Angiocardiography, Significance, and Coexisting Anomalies<sup>1</sup>

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## INTRODUCTION

Persistent left cranial venae cavae were observed in angiocardiograms of 3 dogs at the University of Pennsylvania Veterinary Hospital. Although this vessel seldom has clinical significance, it is hoped this report will spare others the confusion caused by the first case in this series. These 3 dogs and 5 out of 7 others had significant cardiovascular anomalies in addition to persistent left cranial venae cavae.

## LITERATURE REVIEW

At least 12 authors have reported the presence of this anomaly in 20 dogs (2-4, 14, 18-25). Only 1 dog was reported to have a coexisting cardiovascular anomaly (persistent right aortic arch) (23). One investigator found 2 cases in "at least 200 dogs" used for coronary circulation experiments (22). No authors included angiocardiographic demonstration of a persistent left cranial vena cava.

## CASE HISTORIES

**CASE I (1089-E):** A 6-week-old male German Shepherd Dog had a persistent right aortic arch. Angiocardiography is not usually done in this condition as the diagnosis of vascular ring obstruction of the esophagus can be established radio-

graphically in most instances by a barium study of the esophagus. This dog, however, had an electrocardiographic abnormality of questionable significance: negative T wave in an exploring electrode on the right thoracic wall. For this reason angiocardiograms were made.

In the first series of lateral angiocardiograms an abnormal venous return to the heart was observed (Fig. 1). Radiopaque dye<sup>3</sup> injected into the cranial vena cava through a catheter in the left jugular vein entered the heart in its caudodorsal quadrant (in normal dogs the cranial vena cava

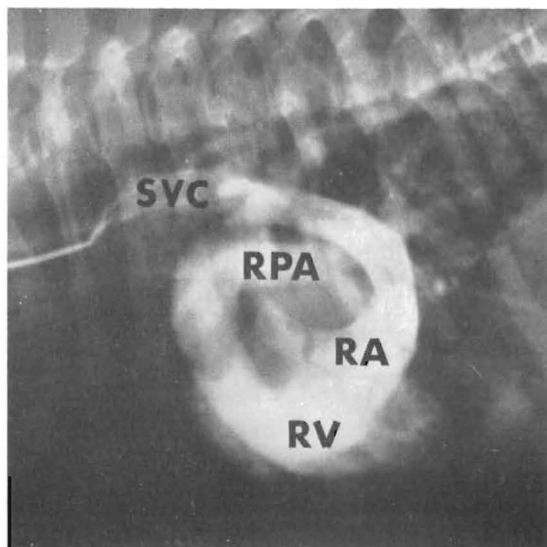


Fig. 1. Case I. Lateral angiocardiogram showing a large persistent left cranial vena cava (SVC) coursing caudally over the base of the heart before opening into the dorsocaudal angle of the right atrium (RA). The right ventricle (RV), main pulmonary artery, left pulmonary artery, and right pulmonary artery (RPA) are also opacified.

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<sup>3</sup> Cardiografin® 85% (0.5 c.c. per lb. of body weight) E. R. Squibb and Sons, New York.

enters the right atrium in the craniodorsal quadrant of the heart). From this location, the dye passed ventrally into the right ventricle. Beyond this chamber, the dye followed a normal course in opacifying the pulmonary arteries, left atrium, left ventricle, and aorta. In dorsoventral angiocardiograms, the abnormal vein was not seen due to incorrect timing of the exposures. The aorta, however, was observed coursing to the right of the air filled trachea, thus confirming the presence of a persistent right aortic arch.

Constriction of the esophagus in dogs with a persistent right aortic arch occurs, in most cases, because the esophagus and trachea are encompassed by a vascular ring consisting of the aorta on the right, the ligamentum arteriosum dorsally, the pulmonary artery on the left, and the base of the heart ventrally (7).

Surgery was performed with the intention of relieving the constriction by transecting the ligamentum arteriosum. When the heart was exposed a large vein was observed crossing over the area of the ligamentum arteriosum and obscuring it from view. The significance of this unusual vessel was not appreciated at this time. The dog was destroyed at the owner's request.

At postmortem examination the abnormal vein was found to be a persistent left cranial vena cava (Fig. 2). The vessel passed through the pericardium at its left dorsocranial reflection and coursed ventrocaudally lateral to the left pulmonary artery. The left atrial appendage was slightly compressed where the vena cava crossed over it. The adventitia of the vessel became continuous with the epicardium as the vessel came to lie in the coronary sulcus. It followed the coronary groove medially and received the coronary veins into its ventral aspect before becoming, by definition, the coronary sinus. The vessel opened into the caudomedial wall of the right atrium adjacent to the orifice of the caudal vena cava. No remnant of a right cranial vena cava was found.

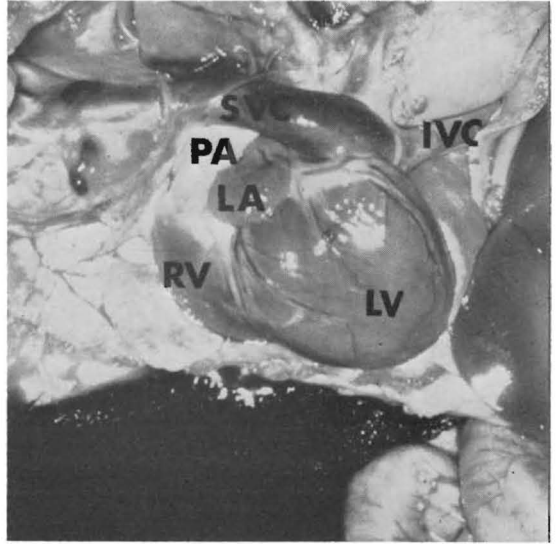


Fig. 2. Case I. Lateral view of the thoracic viscera at necropsy with the left lung lobes reflected dorsally. After entering the pericardial cavity, the persistent left cranial vena cava (SVC) passes lateral to the pulmonary artery (PA) and dorsally over the left atrium (LA) before curving medially in the coronary sulcus to enter the right atrium adjacent to the caudal vena cava (IVC). Left ventricle (LV). Right ventricle (RV).

**CASE II (3748-F):** A one-year-old female Boston Terrier had an interventricular septal defect. The dog was catheterized through the left jugular vein after extensive dissection failed to reveal the right jugular vein. Radiopaque dye injected into the cranial vena cava followed a path similar to that observed in Case I (Fig. 3). Surgery and postmortem examination confirmed the presence of a persistent left cranial vena cava. A normal right cranial vena cava was present.

**CASE III (4980-F):** A 5-month-old male Irish Setter had a persistent right aortic arch. Because of the findings in Case I, angiocardiograms were made. In spite of repeated attempts to pass a catheter into the right atrium with fluoroscopic guidance, the catheter invariably passed up the azygos vein. For this reason, dye was injected near the orifice of the azygos vein. Retrograde filling of the azygos vein was observed immediately after dye injection. The terminal part of a normal

right cranial vena cava and its entrance into the right atrium was also seen (Fig. 4a). One and a half seconds later the vertebral vein system paralleling the azygos vein was opacified. A hemiazygos vein was observed extending ventrally from the fifth thoracic vertebra. It first paralleled the azygos vein for a distance of 3 cm., then curved ventrocaudally from above the bifurcation of the main pulmonary artery where it opened into the proximal segment of a persistent left cranial vena cava. The vena cava extended caudally to the dorsocaudal angle of the heart where it again turned in a ventral direction and entered into the caudal aspect of the right atrium in the region of the orifice of the caudal vena cava (Fig. 4b).

**CASE IV (3749-G):** An 8-month-old male Wire Haired Fox Terrier had a Tetralogy of Fallot. Selective angiocardiology with dye injection into the right ventricle through a catheter passed down the right jugular vein failed to show the presence of a small persistent left cranial vena cava which was later found at surgery. An unsuccessful attempt was made to anastomose the aorta to the left pulmonary artery to provide more blood flow through the lungs. At postmortem examination the persistent left cranial vena cava was found to have the same course as in Cases I and II described earlier.

## DISCUSSION

Rabbits normally have 2 complete cranial venae cavae which follow the same course as is described in most reported cases of persistent left cranial vena cava in dogs (19). Angiocardigrams of a rabbit after simultaneous injection of dye into the right and left jugular veins demonstrate the relationships of the right and left cranial venae cavae (Figs. 5a and b.)

Discussions of embryology to account for the persistence of left cranial venae cavae have been published elsewhere (6, 19). For orientation, only a brief review will be presented here.

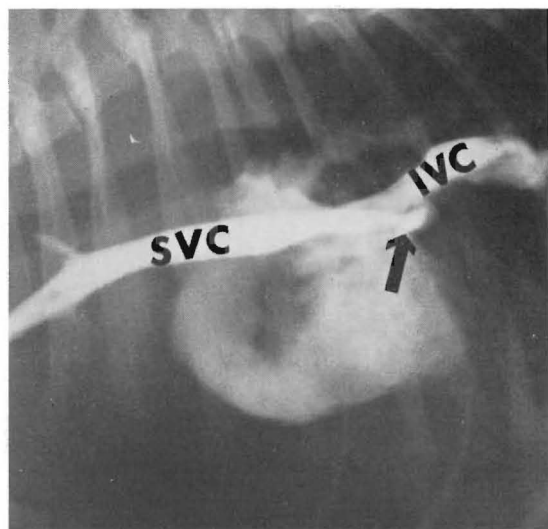


Fig. 3. Case II. Lateral angiocardigram showing a persistent left cranial vena cava (SVC) with basically the same course as in case I but of smaller size since the right cranial vena cava was also present (not opacified). Reflux flow of dye during injection opacified the caudal vena cava (IVC). The relationship of this vessel to the orifice of the coronary sinus can be seen (arrow).

The earliest form of venous return to the primitive heart is through the paired cranial and caudal cardinal veins which are joined to the transversely positioned sinus venosus by the right and left common cardinal veins (Ducts of Cuvier). Normally the right and left cranial cardinal veins are joined cranial to the heart at a later stage by direct fusion (in dogs and cats) or by the development of an anastomosing vein (in man) (19). The remainder of the left cranial cardinal vein atrophies caudal to the fusion while the corresponding right sided vessel enlarges and forms the distal part of the definitive right cranial vena cava. The proximal part of the right cranial vena cava is formed by the right common cardinal vein. The proximal part of the right caudal cardinal vein and the right supracardinal vein (which is dorsal to the right caudal cardinal vein) form the azygos vein in man, dogs, cats, and horses. In these species the majority of the left cardinal system at-

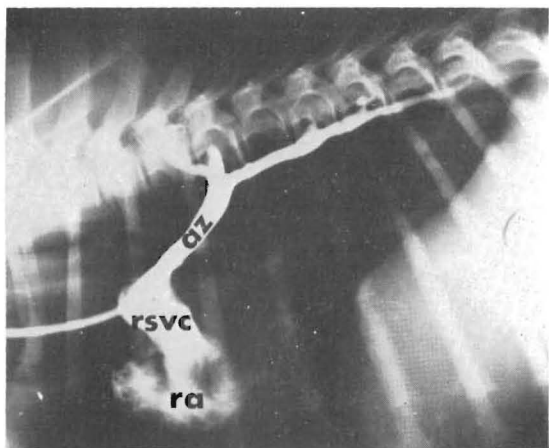


Fig. 4a. Case III. Lateral angiocardigram showing retrograde filling of the azygos vein (az). The proximal part of the right cranial vena cava (rsvc) and its opening into the right atrium (ra) can also be seen.

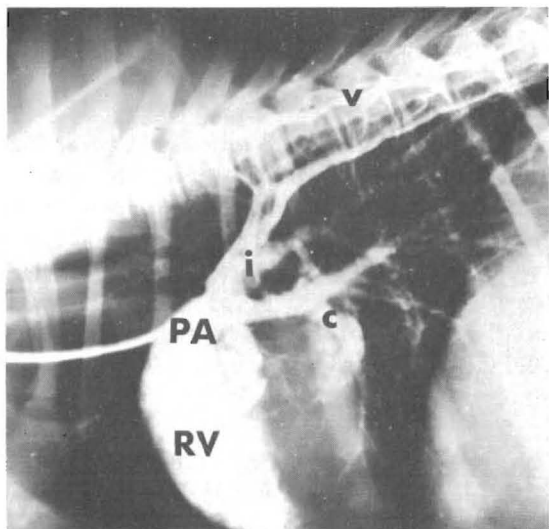


Fig. 4b. Case III. Lateral angiocardigram made  $1\frac{1}{2}$  seconds after the one in Figure 4a. The middle thoracic vertebral veins (v) are opacified. A hemiazygos vein (i) courses ventrally from the level of T<sub>5</sub>. Initially it parallels the azygos vein then curves caudally, opening into the proximal segment of a persistent left cranial vena cava (c) which curves ventrally (and medially) before opening into the dorsocaudal angle of the right atrium. The right ventricle (RV) and pulmonary arteries (PA) are also opacified.

rophies; the left common cardinal vein persists, forming the coronary sinus. In cattle and swine more of the left cardinal system persists. The proximal part of the left caudal cardinal vein and the left supracardinal vein form a hemiazygos vein. The azygos vein is usually absent.

The azygos vein on the right or the hemiazygos vein on the left (depending on the species) joins the proximal segment of the corresponding right or left cranial vena cava (right or left common cardinal vein). In this paper the author has designated the dogs in which the entire left cranial vena cava has persisted as having a complete left cranial vena cava. Those dogs in which only the proximal portion of the left cranial vena cava has persisted and into which a hemiazygos vein has opened are designated as having an incomplete left cranial vena cava.

Persistence of all or part of the left cranial vena cava does not have clinical significance when the vessel opens into the right atrium as in all the cases thus far reported in dogs. In a small percentage of the cases reported in humans the persistent left cranial vena cava has opened into the left atrium and caused cyanosis when sufficient unoxygenated blood bypassed the lungs through this route (9, 15). It is important to recognize this vessel in patients undergoing cardiopulmonary bypass since some procedures call for cannulation of the cranial and caudal venae cavae for venous drainage to the bypass pump.

Two types of persistent left cranial venae cavae have been reported in the dog. The complete type is illustrated in Cases I and II where the left cranial vena cava receives blood from veins cranial to the heart. In 17 reported cases of this type as far as can be determined the right cranial vena cava was also present. In 2 cases, however, no evidence of a right cranial vena cava was found (as in Case I) (20, 25).

An incomplete form of left cranial vena cava resembling the type demonstrated in Case III has been described. In this case, cited in the literature (18), the proximal

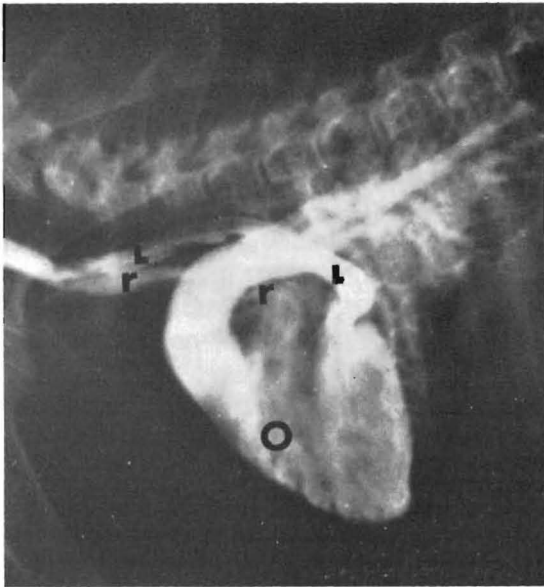


Fig. 5a. Lateral angiocardigram of a rabbit after simultaneous injection of dye into both cranial venae cavae. The left cranial vena cava (L) lies dorsal to the right cranial vena cava (r) and courses in a caudal direction over the base of the heart before opening into the caudal aspect of the right atrium. Stream flow of dye through the right atrium and into the right ventricle is quite apparent in this angiocardigram. Complete mixing does not take place until the dye reaches the outflow portion of the right ventricle (O).

portion of the left cranial vena cava received a vein which drained the left costocervical-vertebral trunk.

A functionally important type of left cranial vena cava has been described in five cats (5, 10-12, 19). In these cases, the right atrial orifice of the coronary sinus was not patent. The left cranial vena cava served to conduct the coronary sinus venous blood in a retrograde fashion to anastomoses cranial to the heart, through which the blood reached the right cranial vena cava and thence the right atrium. It is not likely that this type can be demonstrated angiocardigraphically. Three other cases of persistent left cranial vena cava have been reported in cats (8, 13, 16).

Because of abnormal venous findings in two cases of persistent right aortic arch in this series, 7 available museum speci-

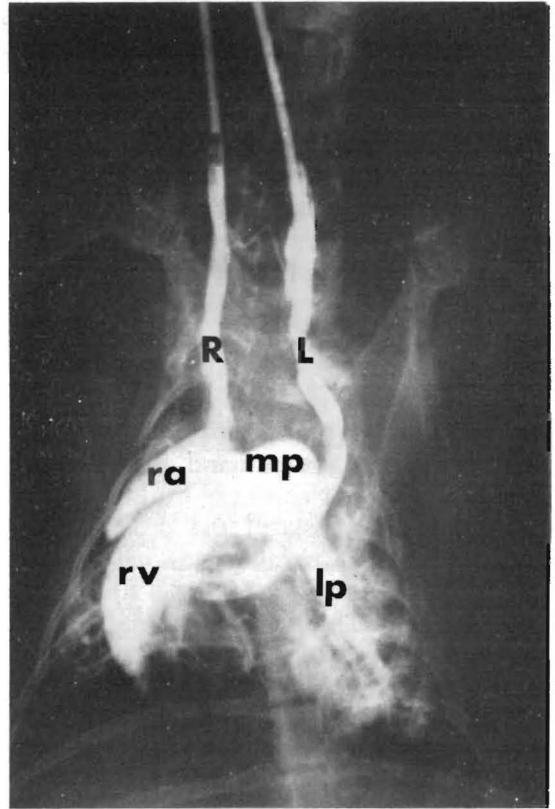


Fig. 5b. Dorsoventral angiocardigram of a rabbit after simultaneous dye injection into both cranial venae cavae. The right cranial vena cava (R) follows the same course as in normal dogs. The left cranial vena cava (L) crosses to the right side caudal to the left atrium which is not opacified. Right ventricle (rv). Right atrium (ra). Main pulmonary artery (mp). Left pulmonary artery (lp).

mens with persistent right aortic arch were re-examined. In 2 of these, incomplete persistent left cranial venae cavae were found and in 2 others vascular segments remained which probably were terminal portions of this anomalous vessel. Since the pericardial sac had been removed from all the specimens, most of a left cranial vena cava would also have been removed; however, photographs of 1 of these specimens (male Irish Setter—64182) were available in which an incomplete type of left cranial vena cava could be seen. In the surgical report of another (male Weimereiner—1118-D), an incomplete type of



left cranial vena cava was also described. In these 2 museum specimens and in two others (65839, 28962) a short segment of a thin walled vessel was present on the caudolateral wall of the left atrium and communicated with the coronary sinus after entering the coronary sulcus just caudal to the left atrial appendage. This was the same location as the entrance of the left cranial vena cava in the 4 cases described earlier in this paper. These vessel segments were of larger diameter than a normal oblique vein of the left atrium. In addition, a ligament of Marshall (a narrow fibrous band on the caudal wall of the left atrium resulting from atrophy and fibrosis of the proximal segment of the left cranial vena cava) could not be located in any of the 4 specimens. It is likely, therefore, that these vascular segments were parts of complete or incomplete left cranial venae cavae. In the literature one case was described in which a persistent right aortic arch was associated with 2 complete cranial venae cavae in a dog.

Three museum specimens (in a large collection of congenital heart disease specimens) had persistent left cranial venae cavae. In 2 of these, other cardiovascular anomalies were present. A 5-week-old male Keeshund had a patent ductus arteriosus, retroesophageal right subclavian artery, persistent innominate vein, and 2 complete cranial venae cavae. A stillborn female Keeshund had a Tetralogy of Fallot in addition to 2 complete cranial venae cavae. The third specimen (a 2-day-old male German Shepherd Dog-Pointer crossbreed with polydactyly) had 2 complete cranial venae cavae but no other detectable cardiovascular anomalies (17).

An additional case of complete persistent left cranial vena cava was observed during postmortem examination of an 11-year-old female Cocker Spaniel dog. The dog had died of congestive heart failure caused by chronic left atrioventricular valve disease. The anomalous vessel was  $\frac{1}{3}$  the diameter of the normal appearing

right cranial vena cava. No other congenital anomalies were found.

In 19 of 20 dogs reported in the literature no mention was made of coexisting anomalies. This is in contrast to cases observed at this hospital and the findings in man. In 1 human series, persistent left cranial venae cavae were found in 2 per cent of patients with non-transposition types of congenital heart disease, and in 40 per cent of patients with some form of visceral or cardiac transposition (9).

The association of other anomalies in cases observed at this hospital corresponds more closely to the findings in humans in that 7 out of 10 definite cases of persistent left cranial vena cava also had some type of congenital transposition: 4 had persistent right aortic arch, 2 had Tetralogy of Fallot, and 1 had a retroesophageal right subclavian artery in addition to other abnormalities.

The right cranial vena cava was entirely absent in 3 out of 30 dogs (2 out of 20 in the literature and 1 out of 10 in this report). This frequency (10 per cent) also corresponds to the findings in man. In one review of 175 cases of left cranial vena cava in man, the right cranial vena cava was absent in 18 (about 10 per cent) (1).

In view of the fact that 8 out of the 10 cases found at this hospital were observed in a  $2\frac{1}{2}$  year period of time, it is likely that this anomaly occurs more often than is apparent from the literature. More cases of this anomaly will probably be detected in the future by angiocardiography if the left jugular vein is used for catheterization, particularly in those cases suspected of having some type of transposition.

## SUMMARY

At the University of Pennsylvania, persistent left cranial venae cavae opening into the right atrium were found in 10 dogs. Four dogs also had a persistent right aortic arch and 4 had other cardiac anomalies. In the literature, only 1 dog out of 20 reported with left cranial venae cavae had

a coexisting anomaly (persistent right aortic arch).

This abnormal vein is not clinically significant unless it opens into the left atrium; however, knowledge of its appearance will aid in angiocardiographic interpretation. Lateral angiocardiograms of 2 dogs with complete persistent left cranial venae cavae showed the abnormal vein crossing over the base of the heart in a caudal direction before entering the right atrium at its caudal angle. Angiocardiograms of another dog showed an incomplete type of left cranial vena cava.

The relationship of right and left cranial venae cavae was demonstrated in angiocardiograms of a rabbit, in which both vessels are normally present.

In 5 out of 8 cats reported in the literature with a persistent left cranial vena cava, the right atrial orifice of the coronary sinus was not patent. The left cranial venae cavae apparently carried coronary venous blood in a retrograde direction.

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## ADDENDUM

Since this article was submitted for publication, an additional case of complete persistent left cranial vena cava has been observed in a 6-month-old male black Cocker Spaniel dog with an interventricular septal defect (Case 4623-G). It was diagnosed by the abnormal course of a catheter in the left jugular vein passed into the heart under fluoroscopic guidance. A dorsoventral angiocardiogram was made and a persistent left cranial vena cava observed. The remaining catheterization studies could not be accomplished with this catheter because of the angle at which it entered the right atrium. A second catheter was introduced through a femoral vein and the catheterization study was completed. The presence or absence of a normal right cranial vena cava was not determined (17).

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## ZUSAMMENFASSUNG

An unserer Kleintierklinik wurde der Befund einer Vena cava cranialis sinistra persistens bei 10 Hunden erhoben. Vier dieser Hunde besaßen dazu einen persistierenden rechten Aortenbogen, während bei 4 weiteren Tieren andere Herzmissbildungen festgestellt wurden. In der Literatur 20 Fälle dieser Missbildung, d.h. Vena cava cranialis sinistra persistens berichtet, von denen jedoch nur ein Fall die gleichzeitig vorhandene Anomalie eines persistierenden rechten Aortenbogens zeigte.

Diese eben erwähnte Missbildung der linken Vena cava ist nur dann von klinischer Bedeutung, wenn die Vene in die linke Herzvorkammer mündet. Die Kenntnis ihres Aussehens wird aber die Auswertung des Angiokardiogrammes erleichtern.

Im Angiokardiogramm (laterale Ansicht) bei 2 Hunden mit vollkommener Persistenz der linken kranialen Vena cava erstreckte sich diese Vene über die Herzbasis in kaudaler Richtung, bevor sie in den rechten Vorhof mündete. Ein anderer Hund zeigte im Angiokardiogramm den "inkompletten" Typ dieser Anomalie.

Das Verhältnis der rechten und linken kranialen Vena cava wird am Angiokardiogramm eines Kaninchens gezeigt. Bei diesem Tier sind normalerweise beide Gefäße vorhanden.

Bei 5 von 8 Katzen mit dieser Missbildung, die in der Literatur beschrieben sind, war die Öffnung des Sinus coronarius in den rechten Vorhof geschlossen. In diesem Fall strömte anscheinend das venöse Blut rückläufig von den Kranzgefäßen durch die linke kraniale Vena cava.

## RÉSUMÉ

A l'Université de Pennsylvanie on a observé chez chiens une ouverture persistante de la veine cave craniale gauche dans l'oreillette droite, 4 de ces animaux avaient en outre une arche aortique droite persistante, et 4 autres différentes anomalies cardiaques. Seulement un chien sur 20 dont on a rendu compte dans la littérature comme ayant une veine cave craniale gauche, avait une anomalie concomitante (arche aortique droite persistante).

Cette veine anormale n'est pas significative pathologiquement a moins qu'elle ne s'ouvre dans l'oreillette gauche néanmoins une connaissance de son apparence peut aider pour l'interprétation angiocardigraphique. Les angiocardigrammes latéraux de 2 chiens avec une veine cave gauche craniale complètement persistante montrent la veine anormale croisant au dessus de la base du coeur dans la direction caudale avant d'entrer dans l'oreillette gauche à son angle caudal. Les angiocardigrammes d'un autre chien montrent un type incomplet de veine cave craniale gauche.

La relation entre les veine cave craniales gauche et droite ont été observées dans les angiocardigrammes d'un lapin chez lequel les deux vaisseaux sont normalement présents.

Cinq chats sur 8 dont on a rendu compte dans la littérature comme ayant une veine cave gauche craniale persistante, avaient un sinus coronaire dont l'orifice dans l'oreillette droite n'était pas ouvert. Le veine cave gauche craniale apparemment transportait le sang veineux coronaire dans une direction rétrograde.