Persistent Left Cranial Vena Cava in Dogs: Angiocardiography, Significance, and Coexisting Anomalies

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Abstract
Persisted left cranial venae 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.

Disciplines
Cardiology | Medicine and Health Sciences | Veterinary Medicine

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Persistent Left Cranial Vena Cava in Dogs: Angiocardiography, Significance, and Coexisting Anomalies

JAMES W. BUCHANAN, B.V.Sc., D.V.M.

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 dye3 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...
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.

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 into the right vertebral vein (4a). One azygos vein was observed and at the fifth thoracic level the azygos vein was divided and the terminal part of a persistent right cranial vena cava (Fig. 4a).

CASE IV (3748-F): A Wire Haired Fox Terrier of Fallot, with dye injected through a right jugular vein into the cranial vena cava (Figs. 5a and 5b). A small persistent left cranial vena cava was later found at postmortem examination, confirming the presence of a normal left cranial vena cava.

DISCUSSION

Rabbits have a single persistent left cranial vena cava. Thus, the course as is the case in dogs (19). However, in dogs (19), the right atrioventricular sulcus of the dog. For orientation and presentation, the presence of a persistent left cranial vena cava has been described.
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 cranial vena cava and the right supracardinal vein (which is dorsal to the right cranial cardinal vein) form the azygos vein in man, dogs, cats, and horses. In these species the majority of the left cardinal system atrophies.
Fi;J.4a. Case III. Lateral angiogram 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.

Fi;J.4b. Case III. Lateral angiogram made 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 T5. 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.

Fig. 5a. Lateral simultaneous injection into the right cranial and left caudal veins. The left superior vena cava (s) courses craniodorsally to the right cranial vena cava (c), which is the more cranial of the two. A persistent left cranial vena cava (PA) also shown. Stenosis of the azygos vein (az) and its opening into the right atrium (ra) is also demonstrated. Figure 5b. Case III. Lateral angiogram made 1/2 seconds after the one in Figure 5a. The middle thoracic vertebral veins (v) are opacified. A hemiazygos vein (i) courses ventrally from the level of T5. 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. Stenosis of the azygos vein (az) and its opening into the right atrium (ra) is also demonstrated. Figure 5c. Case III. Lateral angiogram made 1/2 seconds after the one in Figure 5b. The middle thoracic vertebral veins (v) are opacified. A hemiazygos vein (i) courses ventrally from the level of T5. 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. Stenosis of the azygos vein (az) and its opening into the right atrium (ra) is also demonstrated. Figure 5d. Case III. Lateral angiogram made 1/2 seconds after the one in Figure 5c. The middle thoracic vertebral veins (v) are opacified. A hemiazygos vein (i) courses ventrally from the level of T5. 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. Stenosis of the azygos vein (az) and its opening into the right atrium (ra) is also demonstrated.

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 portion of the left cranial vena cava has opened into the right atrium, but the entire left cranial vena cava persists as having a complete left cranial vena cava. In some cases 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.

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Cardinal veins enter the sinus. In dogs, the left cardinal vein is the noncardinal part of the left cranial vena cava, and the left hemiazygous is absent.

Depending on which segment of the left cranial vena cava remains noncardinal (left or right), the entire left cranial vena cava has been described as having been persistent. Those portions of the cranial portion of the right cranial vena cava that has persisted have been described as having an incomplete connection with the left cranial vena cava.

Most of the left cranial venae cavae that have clinical significance drain into the right cranial vena cava. Cases thus far reported have only a small percentage of the left cranial vena cava used as a functional right cranial vena cava when the persistent right aortic arch was present. The persistent right aortic arch was present in 2 cases (20, 25). It is not likely that this type can be demonstrated angiocardiographically. 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 specimens with persistent right aortic arch were re-examined. In 2 of these, incomplete persistent left cranial vena 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 one 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-weeks-old male Keeshund had a patent ductus arteriosus, retroesophageal right subclavian artery, persistent inominate 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 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 visceror 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 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 aortic arch.

This abnormality is significant in that it connects the right atrium; however, its importance will await further interpretation. In 19 of 20 dogs with complete cranial venae cavae crossing over the right atrium at the cardiac diaphragms of the normal type was observed.

The relationship of the venae cavae to the right atrium on cardiograms of the normal type is vessels are normal.

In 5 out of 6 dogs with a persistent right aortic arch, the right atrium was not patent, the vena cavae appeared normal, the blood in a retroesophageal right subclavian artery in addition to other abnormalities.

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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 without a corresponding vena azygos und coronaria cordis bei Saugetieren. Müllers Arch. 1848. (quoted from Schaller.)


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.


Das Verhältnis der rechten und linken cranialen 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 craniale Vena cava.

RESUME

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 litterature comme ayant une veine cave craniale gauche, avait une anomalie concomittante (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 angiocardiographique. Les angiocardiograms latéraux de 2 chiens avec une veine cave gauche craniale complètement persistante montrent la veine anormale croisant au dessus de la base du cœur dans la direction caudale avant d'entrer dans l'oreillette gauche à son angle caudal. Les angiocardiograms 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 angiocardiogrammes d'un lapin chez lequel les deux vaisseaux sont normalement présents.

Cinq chats sur 8 dont on a rendu compte dans la litterature 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 apparent transportait le sang veineux coronaire dans une direction rétrograde.