



Case report

DOUBLE *VENA CAVA CRANIALIS* IN A FEMALE PUG –
A CASE REPORT

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Summary

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The purpose of the present case report was to describe an extremely rare variation of *vena cava cranialis* in a Pug dog observed during routine dissection. The right cranial vena cava was normally represented, while the left cranial vein was described as an exception and very rarely in mammalian orders with an asymmetric cranial hollow vein, while there are animal classes and orders in which the double, symmetrical cranial hollow vein is normally present. The different end in the right atrium of this extra vein, visualised by imaging methods, can be misinterpreted as pathology of the heart. The left cranial vena cava is an important finding during radiological examination, as well as for specialists dealing with breeding and hereditary anomalies.

Key words: dog, persistent left cranial vena cava, Pug, right cranial vena cava

INTRODUCTION

The cranial vena cava (*v. cava cranialis*), formerly called precava is an unpaired vessel, 1.5 to 2 cm in diameter and 8 to 12 cm long in the dog (Evans & de Lahunta, 2013). It lies in the cranial mediastinum ventral to the trachea and is in contact with the oesophagus on its left side. *Vena cava cranialis* runs right through the cranial mediastinum and is the most ventral of the several structures that course through the thoracic inlet. It is formed, at a level just cranial to the thoracic inlet, by the convergence of the

right and left brachiocephalic veins in the dog (Schaller, 2007; Bezuindenbout, 2013; Vodenicharov, 2021). These form an angle, open cranially, of approximately 90 degrees, so that each vein enters the cranial vena cava at an angle of approximately 45 degrees with the median plane (Bezuindenbout, 2013; Georgiev, 2020a). Its formation is specified on CT angiography against the caput vertebrae of the first thoracic vertebra in the dog in a previous study of ours (Georgiev, 2020a). The cranial vena cava empties into the

cranial part of the right atrium (Bezuindenbout, 2013) or into sinus venarum cavarum through *osteum venae cavae cranialis*, cranially of *tuberculum intervenosum* (Schaller, 2007; Vodenicharov, 2021).

During the embryonic development all the vertebrates present double cranial vena cava (Amorim Jr. & Amorim, 2002). Bilaterally symmetrical cardinal veins, divided into caudal and cranial portions, are formed soon after the development of the dorsal aortae. The right and left caudal cardinal veins are found dorsolateral to the mesonephros and carry blood from the caudal portion of the body and the mesonephros to the heart. The right and left cranial cardinal veins carry blood from the cranial portions of the body, including the head, to the heart. At the level of the heart, the cranial and caudal cardinal veins on each side fuse to form the common cardinal veins (or duct of Cuvier). These initially open into the sinus venosus (together with the vitelline and umbilical veins) through the right and left sinus horns (Hyttel, 2010; De Russi & Carvalho, 2019). The system of the cranial vena cava in vertebrates can be unified or bilateral, and this is summarised by O'Farrel & Griffith (1996) and Amorim Jr. *et al.* (2002) as bilateral *vena cava cranialis* typical for amphibians, reptiles, birds, rodents, hares, marsupials, insectivores, bats, and elephants and as right unilateral in primates, carnivores, ungulates (without elephants), guinea pigs and possums. Kardong (2008) describes bilateral precava on many vertebrates – larval lamprey, shark, lungfish, urodele, adult anuran, turtle, crocodilian, and birds. Double cranial vena cava is indicated in the rabbit (Buchanan, 1963; Pariaut, 2009; Georgiev, 2020a) and Wistar albino rats (De Russi & Carvalho, 2019). Left and right superior vena cava in man exist

only during the first two months of embryonic development (Burney *et al.*, 2007). The mammals that genetically have only one vein, present a transversal anastomosis between the two primitive *vena cava cranialis* or cranial cardinal veins. With the disappearance of this structure on the left, there is a chance for a blood pressure increase and a shorter way to the heart, on the right, where atrophy of the terminal part of the primitive left *vena cava cranialis* occurs caudally from the transverse anastomosis. Thus, the right venous antimer becomes the main route for venous drainage and the dominant *vena cava cranialis*. This fact is observed in the domestic mammals (Amorim *et al.*, 2002; Hyttel, 2010). Cornillie (2008) describes the appearance of the anastomosis at 22–24 mm pig embryo and the atrophy of the caudal portion of the left cardinal vein at 30–35 mm pig embryo.

Persistent left cranial vena cava (PLCVC) is a condition described in a horse (Cox *et al.*, 1991), a cow (Sekeles 1982), a domestic goat (Ranjan *et al.*, 2014), a domestic cat (Caleguiri, 1942; Frontera, 1950). Reports of this anomaly in the dog are also available from Stoland & Latimer (1947), Schaller (1955), Buchanan (1963), Gomercić (1967), Hutton (1969), Buergelt & Wheaton (1970), and Larcher *et al.* (2006). Choi *et al.* (2016) described this condition in 7 different dog breeds. Two types of persistent left cranial vena cava have been reported in the dog. The complete type is illustrated where the left cranial vena cava receives blood from veins cranial to the heart. In 17 reported cases of this type, the right cranial vena cava was also presented as far as it could be determined. In 2 cases, however, no evidence of a right cranial vena cava was found (Zimmerman, 1942; Schroder, 1962; Buchanan, 1963). An incomplete

form of left cranial vena cava resembling the demonstrated type has been described. In this case, cited in the literature, the cranial portion of the left cranial vena cava received a vein which drained the left costocervical-vertebral trunk (Schaller, 1955; Buchanan, 1963) or left hemiazygos vein (Choi *et al.*, 2016).

Persistent left cranial vena cava prevalence is less than 5% in dogs with congenital cardiovascular defects (Buchanan, 1963; Choi *et al.*, 2016). The authors described this anomaly in 2.6% of dogs that underwent thoracic CT examinations, because of reasons unrelated to cardiac anomalies. Most dogs with PLCVC show no clinical signs, an incidental finding of PLCVC might occur at any age. The right cranial vena cava was entirely absent in 3 out of 30 dogs (Buchanan, 1963). This frequency (10 per cent) also corresponds to the findings in man (Atwell & Zoltowski, 1938). In one review of 175 cases of left superior vena cava in man, the right superior vena cava was absent in 18 (about 10 per cent) (Buchanan, 1963). This percent was confirmed in dogs by Choi *et al.* (2016). All patients observed by this team had a complete type PLCVC, which is defined when the non-atrophied left cranial cardinal vein retains connection with the coronary sinus draining to the right atrium. This is because the coronary sinus is a remnant of the embryonal common left cardinal vein or duct of Cuvier (Schaller, 2007; Hyttel, 2010; Vodenicharov, 2021).

Case description

The described condition was found during a routine dissection of a female Pug dog, intact, aged 10 years, which was fixed by formaldehyde and methyl alcohol was introduced through the common carotid artery. The Pug died suddenly during

surgery for castration without any clinical signs. The dog's body was given to the university clinic for autopsy.

Typically, the right cranial vena cava was visualised in the right thoracic cavity half of the dissected dog (Fig. 1) with a length of 4.8 cm. It passed and adjacent to anatomical structures, described in the introduction. Before its end in the right atrium the fully developed right azygous vein flowed into the vein (Fig. 1).

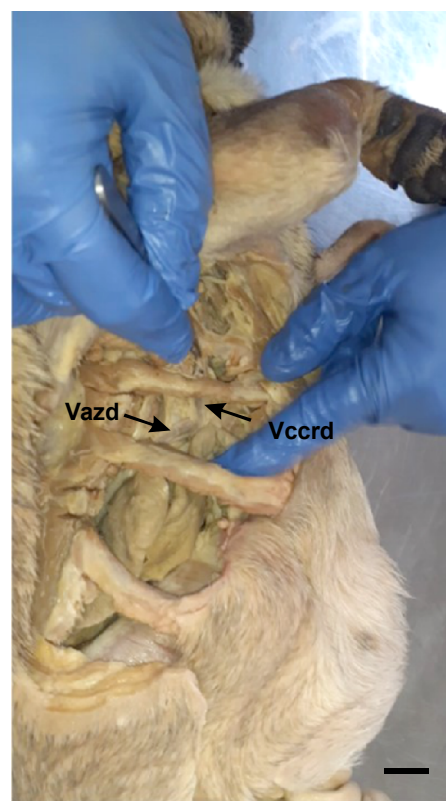


Fig. 1. Right side of pug, lateral view. Vccrd – right cranial vena cava; Vazd – right azygous vein. Bar=2.4 cm.

Cranially of the thoracic inlet, as in all dogs, the left external jugular vein connected to the intrathoracic continuati-

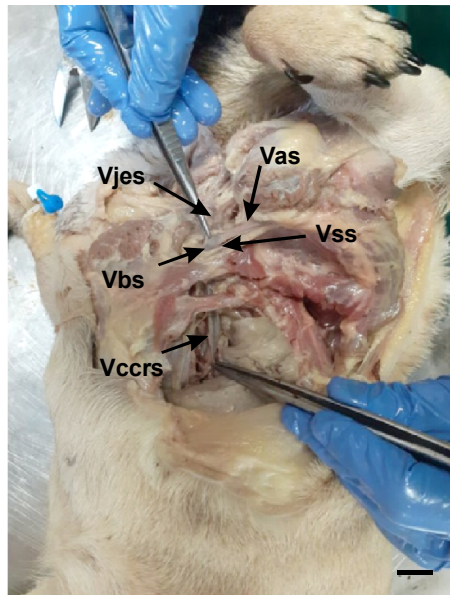


Fig. 2. Left side of pug, lateral view. Vccrs – left cranial vena cava; Vbs – left brachiocephalic vein; Vjes – left external jugular vein; Vas – left axillary vein; Vss – left subclavian vein. Bar = 2.4 cm.

on of the left axillary vein, known as miniature, left subclavian vein, to form a short venous collector called the left brachiocephalic vein (Fig. 2). The difference with this Pug was that the last vein did not merge with the right vein against the caput vertebrae of the first thoracic vertebra and continued to the left in the cranial and middle mediastinum in the middle of the thoracic height as a persistent left cranial vena cava (Fig. 2) with a length of 11.8 cm. It was directed to the left of the pulmonary trunk, then turned caudally from the ascending aorta and emptied into the coronary sinus (Fig. 2; Fig. 3A).

The coronary sinus lay ventrally from the ostium venae cava caudalis and their sinus venarum cavarum on heart's right atrium (Fig. 3B). The embryonic connec-

tion of the left cranial cardinal vein with the left duct of Cuvier was preserved as an end of the persistent left cranial vena cava into the coronary sinus, which was identified bilaterally, shown by the tweezers (Fig. 3A, B).

A schematic presentation of the venous pattern observed in this study in comparison to the normal view is shown on Fig. 4.

Double cranial vena cava is present during the embryonic development of all vertebrates (Amorim Jr. *et al.*, 2002) which was used by us for naming blood vessels in the present canine clinical case. Out of 997 dogs with thoracic contrast-enhanced CT described by Choi *et al.* (2016), only 26 had PLCVC (2.6%) which corresponds to our findings in the Pug and defines it as a rare anomaly. The mean age of the dogs with PLCVC was 10.3 years and all patients were incidentally diagnosed with PLCVC regardless of clinical signs (Choi *et al.* 2016), as confirmed by the present case report. While PLCVC is often asymptomatic, on some occasions it can lead to significant problems such as arrhythmias and cyanosis in humans (Azizova *et al.*, 2020) which were not observed in our case, but should be considered as possible symptoms.

In 19 of 20 dogs reported by Buchanan (1963), no accompanying cardiac abnormalities were detected and diagnosed, which corresponds to studies in dogs with PLCVC (Choi *et al.*, 2016) where this malformation together with cardiovascular anomaly (right ventricular diverticulum or aneurysm) was identified incidentally in one dog from the CT images. Choi *et al.* (2016) reported various clinical signs unrelated to any cardiac abnormalities in 15 of 26 dogs diagnosed with abdominal and thoracic masses together with PLCVC.

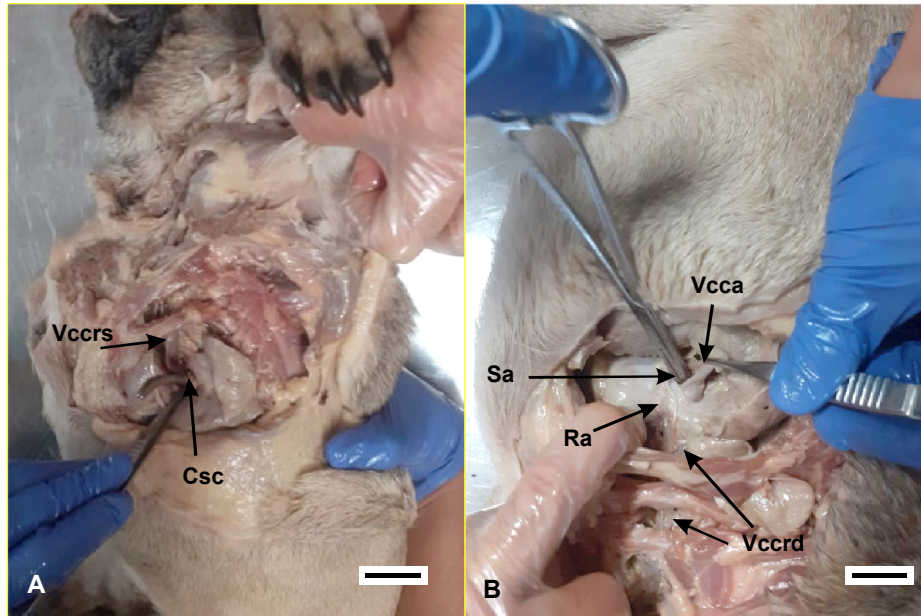


Fig. 3. Left (A) and right side (B) of the pug, lateral view. Vccrs – left cranial vena cava; Vccrd – right cranial vena cava; Vcca – caudal vena cava; Ra – right atrium; Sc – coronary sinus; Csc – connection between left cranial vena cava and coronary sinus shown with the tweezers. Bar (A)=2 cm; bar (B)=2.4 cm.

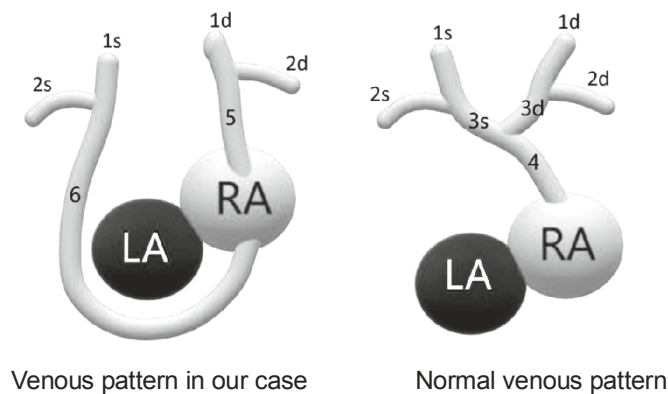


Fig. 4. Venous patterns: RA – right atrium, LA – left atrium, 1s – *v. jugularis sinistra*, 1d – *v. jugularis dextra*, 2s – *v. axillaris sinistra*, 2d – *v. axillaris dextra*, 3s – *v. brachiocephalica sinistra*, 3d – *v. brachiocephalica dextra*, 4 – *v. cava cranialis*, 5 – *v. cava cranialis dextra*, 6 – *v. cava cranialis sinistra*.

PLCVC was described in combination with different cardiac abnormalities in several breeds: German Shepard, Boston

Terrier, Irish Setter, Wire-Haired Fox Terrier, Keeshound (Buchanan, 1963), Beagle (Del Palacio *et al.*, 1997), Cocker

Spaniel, Maltese (Hwang *et al.*, 2016), Lakeland terrier (Jang *et al.*, 2018), Bichon Frise (Jung *et al.*, 2019). PLCVC cases were reported in Shih Tzu, Pekingese, Cocker spaniel, Poodle, German shepherd, English bulldog, and Boston terrier. Shih Tzu and Pekingese dogs were overly predisposed (Choi *et al.*, 2016). PLCVC has been diagnosed in various breeds of dogs including Irish setter, French bulldog, Brittany spaniel and Beagle (Buchanan, 1963; Cunningham & Rush, 2007; Jenni *et al.*, 2009; Zani *et al.*, 2014). The presence of PLCVC is related to genetic factors and the brachycephalic breeds could be predisposed (Jang *et al.*, 2014). For the first time in the present case, complete type PLCVC in a brachycephalic dog – a Pug, was observed. Sometimes PLCVC can cause oesophageal obstruction and consequent megaesophagus in a dog (Larsher, 2006), which is very rare.

The complete type is defined as the state when the left vena cava receives blood from the veins cranial to the heart and the right vena cava is also presented (Zimmerman, 1942; Shroder, 1962; Buchanan, 1963), as the double vena cava reported in our case. The complete type of PLCVC without right vena cava and the incomplete type when the left vena cava drains the left costo-vertebral trunk (Schaller, 1955; Buchanan, 1963) or the left hemiazygos vein (Choi *et al.*, 2016) may be clinically manifested and are very different morphologically from the present case.

Different types of PLCVC were described. The first type was seen in a Cocker spaniel. The dog had an anastomosis between the right and left cranial vena cava at the level of the thoracic inlet, together with dilated coronary sinus, aortic arch calcification, right atrial and

ventricular enlargement, and a large right ventricular outpouching (Choi *et al.*, 2016). A second complete type PLCVC in a Pekingese revealed that the azygos vein coursed slightly along the right side of the aorta, then extended transversely toward the left side and entered the PLCVC at the level of the main pulmonary trunk (Choi *et al.*, 2016). In our case the azygos vein was normally developed on the right, with no connection to the left cranial vena cava and finished into the end of the right cranial vena cava. A third complete type PLCVC was detected in a Poodle without the right cranial vena cava, where the blood from the right jugular vein and the right brachiocephalic vein drains to the PLCVC. In this dog, the left costocervical vein and internal thoracic vein joined the PLCVC, while the right costocervical vein and right internal thoracic vein formed a vessel, that coursed caudally and drained to the right atrium with the right azygos vein. Therefore, this vein looked like a right cranial vena cava (Choi *et al.*, 2016). This type is in great contrast with our case where a double, symmetrical vena cava draining similar areas and anatomic structures in the left and right side of the head, neck, thorax, and thoracic limb except for the right azygos vein was present.

The presentation of PLCVC can be explained by the lack of ontogenetic development of the transverse precardial anastomosis between the two cardinal veins cranially of the thoracic inlet, so the venous blood from the cranial part of the body is drained not only by the right cranial vena cava but also from the non-atrophic left one (Amorim Jr. *et al.*, 2002; Cornillie 2008; Hyttel, 2010; Choi *et al.* 2016). The absence of clinical manifestation or accompanying cardiac abnormalities in PLCVC (Buchanan, 1963; Choi *et*

al. 2016; Azizova *et al.*, 2020) is also confirmed in this case, as phylogenetically double cranial vena cava exists normally in some classes and orders of animals (O'Farrel & Griffith, 1996; Amorim Jr. *et al.*, 2002; Kardong, 2008) that once again illustrates the absence of any clinical signs.

The left *vena cava cranialis* and coronary veins terminate in the coronary sinus, which can be mistaken for a congenital heart defect or early right heart failure in rabbits (Pariaut, 2009), in other pets with a symmetrical *vena cava cranialis*, and in pets with an asymmetrical one (O'Farrel & Griffith, 1996; Amorim Jr. *et al.*, 2002), where the left is persistent. This morphological feature is extremely important for contrast-enhanced computed tomography and echocardiographic examinations of the heart by the veterinary cardiologists.

In conclusion, to our knowledge, this clinical case is the first to describe a complete type of persistent left cranial vena cava in a Pug. This finding is important in the absence of clear external signs and indications for diagnostic imaging study of the dog's heart, as well as in relation to genetic inheritance from brachycephalic individuals or lines, although it is rarely associated with coexisting cardiac abnormalities. Due to the above, we recommend radiological examination of the cardiovascular system in the dogs at an early age and exclusion from breeding even when on detection of a single PLCVC, especially in brachycephalic dog breeds.

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