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NOTE

Anatomy

Common venous renal trunk in two dogs: Multidetector computed tomographic imaging findings

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ABSTRACT. In dogs, variation in the branching pattern of renal veins is rare with only few patterns reported. This report describes two unusual anomalies of the renal vein branching patterns in two dogs. In dog 1, a common renal trunk drained both kidneys, in a T-shape pattern, in the caudal vena cava after a long right perirenal course. In dog 2, a common venous trunk branched cranially from the pre-renal segment of an azygos-caudal vena cava venous trunk and divided into the renal veins in a Y-shape pattern. Proper knowledge of the possible anatomical variations in renal venous drainage may be helpful during imaging assessment and surgical planning of several canine diseases involving the abdominal vasculature and retroperitoneal space.

KEY WORDS: angiography, caudal vena cava, computed tomography, dog, gonadal veins, renal veins

Renal veins are two short, paired venous vessels that originate from the confluence of the renal interlobar veins and join the renal segment of the caudal vena cava (CVC). The left renal vein receives the left gonadal vein, while the right renal vein does not receive the right gonadal vein, which instead drains directly into the caudal vena cava, caudally to the right renal vein. The embryogenesis of the renal and gonadal veins, even if not entirely elucidated yet, is strictly related to the development of the renal segment of the caudal vena cava from embryonal supracardinal and subcardinal venous systems. In cases of developmental errors involving these embryonic venous systems, several anatomical abnormalities of the caudal vena cava have been recognized in dogs, all attributable to two main patterns: double vena cava and segmental aplasia of the caudal vena cava with azygos continuation [1, 3, 6]. These caval anomalies may be intimately related to the cause of malformation of renal and gonadal veins.

Anatomical anomalies of the renal veins are not unusual in the human population, in which several patterns already been codified [4, 16]. However, reports of anatomical variation in renal veins are scarce in veterinary medical literature and limited to descriptions of supernumerary and circumaortic renal veins [8, 12].

Currently, multi-detector-row computed tomographic (MDCT) angiography is a key imaging modality for the assessment of abdominal vasculature in small animals providing adequate contrast, spatial and temporal resolution for both arterial and venous systems [2].

This report describes two cases of renal vein branching anomaly (or variation), as shown by MDCT angiography, and discusses their possible embryogenesis and clinical significance.

Dog 1. A 4-year-old female mixed breed dog was evaluated at the Roges Veterinary clinic, Rende, Italy for acute onset of paraplegia, with T3–L3 neurolocalization, due to a T12–T13 disc herniation. Advanced imaging of the spine was performed using a 16-slice MDCT scanner (Siemens Go.Now; Siemens, Forchheim, Germany) with the patient in sternal recumbency on the CT table under general anesthesia. Computed tomography images were acquired before and 21 sec after the manual intravenous injection of iodinate contrast medium (640 mg I/kg; Iomeron 300® Bracco Imaging SpA, Milan, Italy) in the right cephalic vein, using the following technical parameters: helical modality, standard acquisition algorithm, 110 kVp, 150 mAs, 1-mm slice thickness, 0.5 mm reconstruction interval, pitch of 0.8, and 1 sec/rotation. Three-dimensional (3D) multiplanar reformatted images were obtained using a dedicated 3D software (Pixmeo, OsiriX; OsiriX DICOM-viewer; Pixmeo, Geneva, Switzerland).

The abdominal cavity was included in the field of view of reconstructed images.

CT showed an abnormal conformation of the renal venous system as an incidental finding. A single large venous vessel branched from the right side of the renal segment of the caudal vena cava, ran laterally to the right kidney making a ventro-medial U-turn

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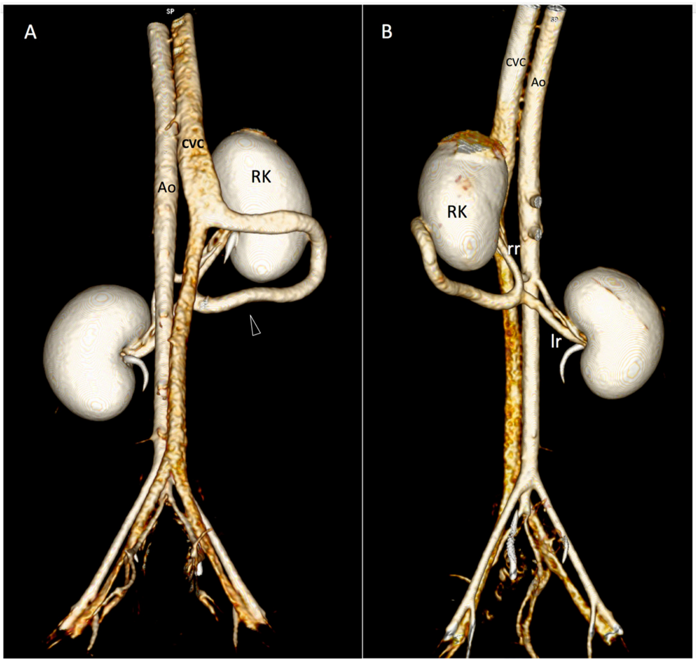

Fig. 1. Dog 1. A) Dorsal and B) ventral 3D-volume rendered MDCT images of the aorta (Ao) and caudal vena cava (CVC) after removal of the skeleton and abdominal organs. Arrowhead points to the single large venous vessel branching from the right side of the renal segment of the caudal vena cava and receiving with T-conformation the right (rr) and left (lr) renal veins. RK, right kidney.

and forked with T-shape giving rise to the right and left renal veins (Fig. 1). The topographic location of both kidneys was normal. The right gonadal vein was short (10 mm) and drained in the common venous trunk laterally to the right kidney, while the left one joined the left renal vein (Fig. 2).

Dog 2. A 10-years-old female Irish setter dog with a 30-days history of weight loss and vomiting underwent a total body MDCT scan at the Roges Veterinary clinic for anatomical characterization of a parietal gastric neoplasm and complete oncological staging. CT scan and post processing image analysis were performed as described for dog 1. As an incidental finding in the abdomen, CT showed enlargement of the azygos vein and the absence of the hepatic and pre-hepatic segment of the caudal vena cava with azygos continuation. The cavo-azygos trunk ran on the right side of the aorta. The pre-renal segment of the caudal vena cava made a ventro-dorso-caudal folding resembling a curl, passed on the left side of the aorta and divided into the common iliac veins (Fig. 3). From this spiral segment a common venous trunk branched cranially and divided into the renal veins in a Y-shape pattern at the level of the L4–L5 intervertebral disc space. The hepatic veins drained directly into the hepatic segment of the caudal vena cava. The gonadal veins were not identifiable. In Fig. 4 a schematic representation of both renal veins branching patterns in dog 1 and 2 is showed.

In dogs, anatomical variations of the pre-renal segment of the CVC have been reported as duplication of the main trunk caudally or at the level of the renal veins [3]. However, to date, description of renal vein anomalies are limited to only two variants: multiple renal veins and a circumaortic venous ring [8, 12].

Conversely, vascular anomalies of the renal veins are largely described in human medical literature and they are classified into different types, five for the left renal vein: type I or circumaortic left renal vein; type II or retroaortic left renal vein; type III or abnormal reflux (adjunctive abnormal renal vein originating from the hilum or the poles of the kidney and draining in the CVC at different levels); type IV or late venous confluence of left renal vein (confluence and union of the interlobar renal veins outside the renal hilum); and type V or rare type (variations of types I and IV), and three for the right renal vein: type I or additional renal veins; type II or abnormal reflux; and type III or rare type (combination of type I and II; Y-shape common renal trunk) [16].

The renal vein anomaly in dog 1 appeared very similar to one included in the type III patterns (rare branching pattern) described in human medical literature for the right renal vein variations [16]. In both cases a common Y/T-shaped venous trunk drained the left and right renal veins before entering the CVC, on the ventral side (human patient) [16] or on right lateral side (our case).

Similarly, dog 2 had an analogous Y-branching pattern of the renal veins, however in this case this venous variation was part of a larger anatomical disorder involving the caudal vena cava and the azygos vein (azygos continuation of the caudal vena cava).

Interestingly, in a previous case series on segmental CVC aplasia with azygous continuation in dogs, seven different anatomical patterns of cavo-azygos shunt were identified, and in the majority of cases, a common renal venous trunk draining into the caval portion of the shunt vessel was observed. However, no CT images of the abnormal renal trunks were available for review [14].

The embryogenetic process leading to the formation of these vascular anomalies in dogs is unknown and the exact developmental mechanism of the caval venous system to date has not been entirely elucidated [5].

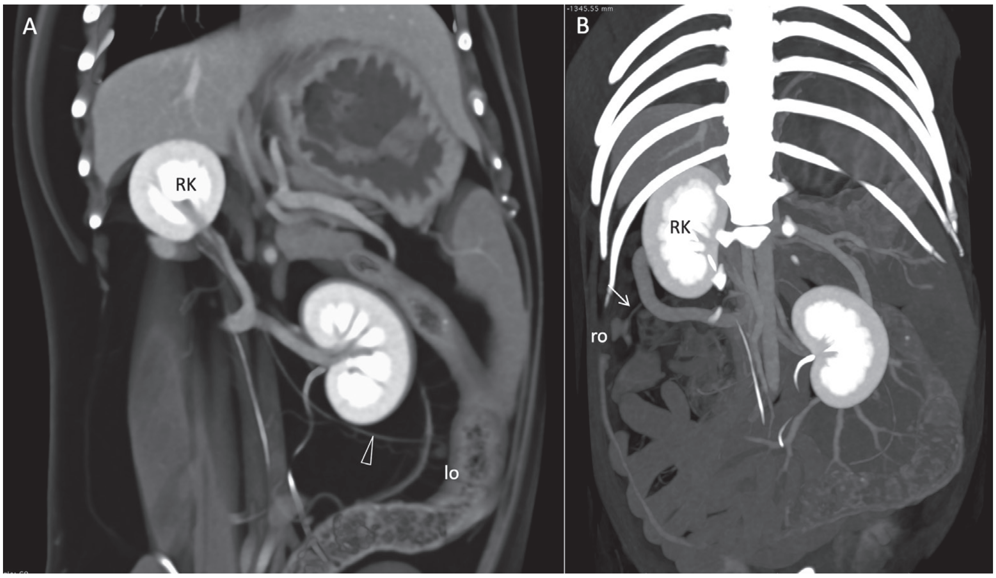

Fig. 2. Dog 1. A) Oblique-dorsal thick-slab volume rendered and B) Maximum intensity projection MDCT images of the abdomen at the level of the renal veins. The left gonadal vein shows normal course joining the left renal vein (A−arrowhead). The right gonadal vein shows abnormal course draining into the common venous trunk (B−arrow). lo, left ovary; ro, right ovary; RK, right kidney.

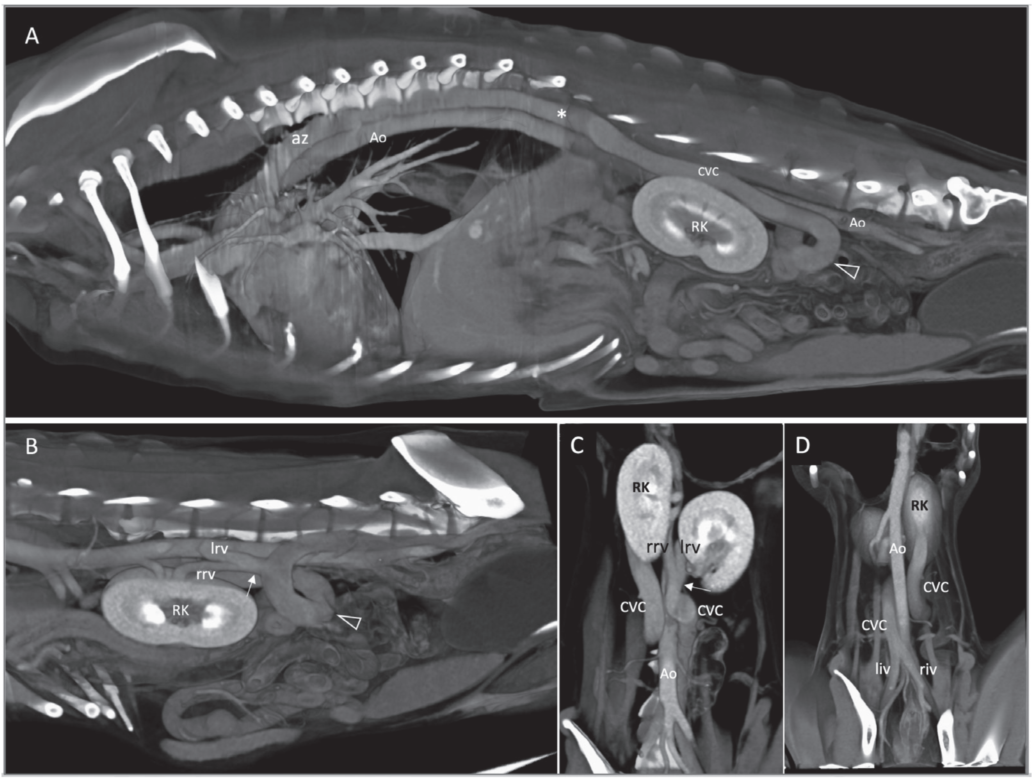

Fig. 3. Dog 2. A) Right oblique-parsagittal thick-slab volume rendered MDCT image of the thoracic and abdominal regions showing a large caval-azygos venous trunk, originating from the shunting of the caudal vena cava (CVC) and azygos vein (az), running on the right side of the aorta (Ao) (*azygos continuation of the caudal vena cava*). Right oblique-parsagittal (B), ventral (C) and dorsal (D) thick-slab volume rendered MDCT images of the pre-renal segment of the caudal vena cava (CVC). The pre-renal segment of the caudal vena cava made a ventro-dorso-caudal folding resembling a curl (arrowheads), passed on the left side of the aorta and divided into the common iliac veins (liv, left common iliac vein; riv, right common iliac vein). From this spiral segment a common venous trunk branched cranially and divided into the renal veins in a Y-shape pattern (arrows). rrv, right renal vein; lrv, left renal vein; RK, right kidney.

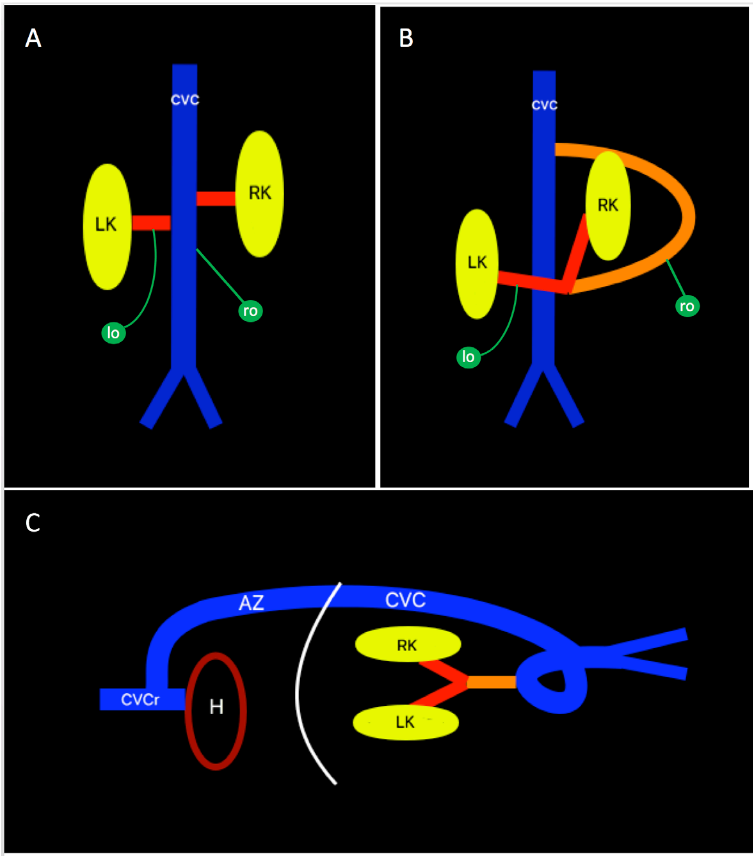

Fig. 4. Schematic representation of the anomalies of the renal vein branching patterns in dog 1 and 2. A) Normal anatomy of the renal vein branching pattern from the caudal vena cava (CVC). B) Branching pattern of the renal veins in dog 1. C) Branching pattern of the renal veins in dog 2. Orange: common venous renal trunk; red: renal veins; green: gonadal veins; lo: left ovary; ro: right ovary; H: heart; CVC: caudal vena cava; CVCr: cranial vena cava; AZ: azygos vein; RK: right kidney; LK: left kidney.

In mammals, the caudal venous system is derived from the embryonic umbilical veins, vitelline veins, and the caudal cardinal system. The caudal cardinal system is formed from a complex process involving development, regression, anastomoses, and the replacement of three pairs of embryonic vessels: the caudal cardinal, supracardinal, and subcardinal veins [5, 11].

Five different models concerning the development of the abdominal venous system are described in mammals: the supracardinal model, the caudal cardinal model, the sacrocardinal model, the lateral sympathetic model, and the subcardinal model [5].

According to the supracardinal model, the cardinal veins are the first to form laterally to the embryonic mesonephros, followed by two bilateral set of veins, the subcardinals and later the supracardinal veins. As the supracardinal veins gradually develop, the subcardinal veins start to degenerate. Multiple anastomoses forms between the subcardinal veins on the midline (intersubcardinal anastomoses) as well as between the subcardinal and caudal cardinal veins on each side, before the caudal cardinal veins start to regress. Only the caudal ends of the caudal cardinal vein persist and form the common iliac veins. Caudally, the supracardinal veins anastomize with caudal cardinal and subcardinal veins (subsupracardinal anastomosis) on both sides while cranially the cranial part of the right supracardinal veins forms the azygos vein. Subsupracardinal anastomosis give rise to the renal veins and to the pre-renal segment of the CVC.

The intersubcardinal anastomoses give rise to the renal segment of the CVC and gonadal veins. the cranial end of the right subcardinal vein join the right vitelline vein (anastomosis subcardinalis-vitellina) to form the hepatic segment of the CVC.

According to the other models, the renal veins originate directly from the subcardinal veins rather than from the subsupracardinal anastomosis [5, 7].

Since the supracardinal and the subcardinal veins are responsible for the final constitution of both the renal segment of the CVC and the renal veins [10] an embryological error involving these veins may be hypothesized for dog 1.

Errors in the fusion between the caudal cardinal system and the right vitelline vein and subsequent failure in the union between the pre-hepatic and renal segments of CVC during embryological development result in the so-called infrahepatic interruption of the inferior (caudal) vena cava with azygos continuation [1, 9]. Hence, in dog 2 a combination of this last embryological disorder in association with errors in the supracardinal and the subcardinal veins may be hypothesized.

To the best of the authors' knowledge, the venous anomalies herein described are the first T/Y-shape branching pattern of the renal veins reported in dogs and greatly contributes to the classification of such anatomical variations in the veterinary medical literature.

Proper knowledge of the possible anatomical variations of renal and gonadal venous drainage may be helpful for avoiding diagnostic pitfalls during imaging evaluation of the abdominal vasculature. Moreover, consideration of these anatomical variations is essential during surgical planning involving the retroperitoneal region and when renal veins need to be identified as landmarks, both for extra- or intravascular surgeries. Unawareness of such conditions during surgical procedures may injure the veins leading to complications or severe bleeding [15].

Finally, as previously reported for other arterial and venous anomalies in dogs [3, 13] these findings confirm that high quality contrast-enhanced MDCT imaging of the abdomen provides adequate angiographic detail to properly assess the anatomical variations of the abdominal vessels.

CONFLICT OF INTEREST. The authors declare that there is no conflict of interest.

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