

Computed Tomography Angiography of Situs Inversus, Portosystemic Shunt and Multiple Vena Cava Anomalies in a Dog

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ABSTRACT. A 5-year-old Shih Tzu was presented with intermittent vomiting and anorexia. Microhepatica and reversed position of the abdominal organs were observed on radiography. Ultrasonographically, portosystemic shunt (PSS) was tentatively diagnosed. Computed tomography (CT) revealed that the distended portal vein drained into the left hepatic vein. The caudal vena cava (CdVC) split postrenally and converged at the renal level. Cranial to this, the azygos continuation of the CdVC was confirmed. In the thorax, a persistent left cranial vena cava (CrVC) was found along with right CrVC. This is the first report of a dog with persistent left CrVC and multiple abdominal malformations. CT angiography was useful in evaluating the characteristics of each vascular anomaly and determining the required surgical correction in this complex case.

KEY WORDS: azygos continuation of the caudal vena cava, CT, persistent left cranial vena cava, portosystemic shunt, situs inversus.

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Situs inversus is a congenital condition in which the visceral position is reversed as a mirror image. This condition is the main characteristic of Kartagener's syndrome with rhinosinusitis and bronchiectasis [7]. Situs inversus without dextrocardia has been reported with congenital vascular anomalies including portosystemic shunts (PSS) and azygos continuation of the caudal vena cava (CdVC) [10, 13, 15].

The abdominal CdVC is divided into prerenal, renal, prehepatic, hepatic and posthepatic segments derived from the supracardinal, subcardinal and vitelline veins [10]. The retained middle segment of the supracardinal vein, normally regressed during normal development, plays a role as the connection between the embryonic CdVC and azygos vein, that is, the azygos continuation of the CdVC. The developing CdVC, usually a prehepatic CdVC, can be inappropriately connected with the caudal portion of the vitelline vein developing into a portal branch, and this abnormal connection between the vessels is a PSS [21].

Persistent left cranial vena cava (CrVC) is an uncommon congenital defect [1]. During embryologic development, the caudal portion of the left cranial cardinal vein, normally atrophied with the fusion of the left and right cranial cardinal veins, persists, resulting in a persistent left CrVC. This condition has been described with other congenital defects of the cardiovascular system [1, 2, 6, 8, 11, 12, 19, 22].

To the authors' knowledge, this is the first report documenting persistent left CrVC with congenital abdominal anomalies including situs inversus, PSS, azygos continua-

tion of the CdVC and split CdVC in a dog. We described the application of CT angiography for distinguishing and comprehending these multiple vascular anomalies and situs inversus in the dog herein.

A 5-year-old, neutered male Shih Tzu was presented with a 2-week history of vomiting and anorexia. On physical examination, there were no abnormal findings including on auscultation. The dog's complete blood count and serum chemistry were within the reference ranges, except for hepatic enzymes, such as alanine aminotransferase (968 U/l; reference range, 19–100 U/l), gamma-glutamyl transferase (22 U/l; reference range, 0–6 U/l), alkaline phosphatase (280 U/l; reference range, 15–127 U/l) and ammonia (143 μ mol; reference range, 0–98 μ mol).

On radiography, microhepatica and reversed position of the abdominal organs with normal thoracic visceral position were found (Fig. 1). Ultrasonography revealed decreased vascular size of the intrahepatic portal vein and hepatic vein and normal echotexture of the hepatic parenchyma. A dilated, tortuous portal branch showing an atypical portal flow signal was found in the left cranial abdomen, and PSS was tentatively diagnosed. Apart from the vessel suspected to be a PSS, there were many tortuous vessels, and it was challenging to determine the characteristics of the tortuous vessels, because of concurrent situs inversus.

To identify the suspicious vessels, CT angiography was performed at 30 sec after injection of 800 mg iodine/kg iohexol (Omnihexol 300, Korea United Pharm Co., Seoul, Korea) at a rate of 3 ml/sec using a power injector (Medrad Vistron CT Injector System, Medrad, Inc., Warrendale, PA, U.S.A.). The distended portal vein showed a convoluted course from the mid to left cranioventral abdomen and joined the left hepatic vein (Fig. 2). A single extrahepatic PSS was confirmed. Additionally, two separate CdVC branches converged at the renal level, and then a single CdVC coursed dorsally and connected

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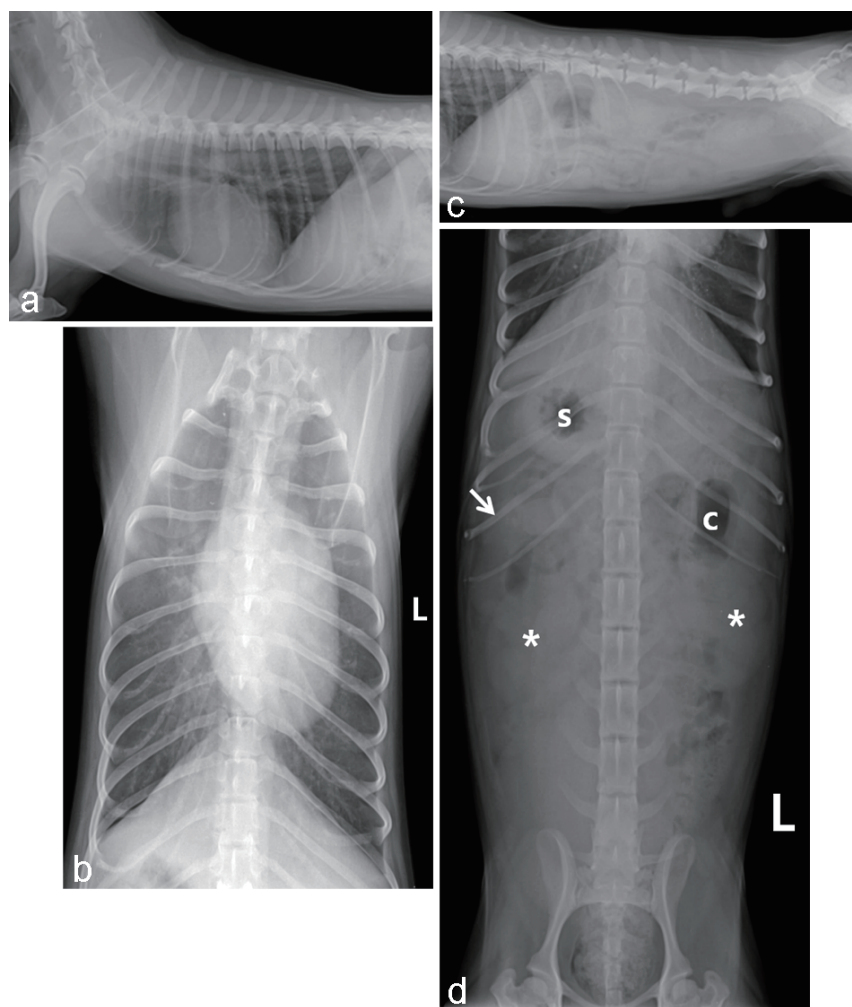


Fig. 1. Thoracic (A, B) and abdominal (C, D) radiography of the dog. There were microhepatica and reversed positions of the stomach (s), spleen (arrow), bilateral kidneys (*) and cecum (c) compared with the normal thoracic visceral positions.

directly to the azygos vein with the prehepatic CdVC being absent (Fig. 3). The positions of the stomach, duodenum, spleen, colon, cecum and kidneys, which had normal shapes and internal structures, were reversed. In the thorax, a left CrVC driving caudally to the caudodorsal angle of the heart and draining into the right atrium was found along with the right CrVC (Fig. 4). There was no other cardiovascular defect, and this was double checked with echocardiography. On the basis of these findings, the dog was diagnosed as having situs inversus; abdominal vascular anomalies including PSS, azygos continuation of the CdVC and split CdVC; and a thoracic vascular anomaly, persistent left CrVC.

Among these lesions, PSS was considered the cause of the clinical signs in the dog, and other congenital malformations were determined to be incidental findings. The PSS was surgically corrected using an ameroid constrictor, and then clinical signs and laboratory data returned to normal.

Situs inversus with rhinosinusitis and bronchiectasis are

classified as Kartagener's syndrome [3, 7, 18]. In Kartagener's syndrome, chronic coughing and nasal discharge are caused by defective cilia motility. Cilia dyskinesia was ruled out in this case because there were no respiratory signs or evidence of bronchiectasis on thoracic radiography, even though electron endoscopy was not performed. Without primary ciliary dyskinesia, situs inversus may not lead to clinical signs. However, this condition can interfere with diagnostic and surgical procedures that require an understanding of the anatomy of the viscera and vascular structures like in this dog.

Ultrasonography has high sensitivity and specificity as a means of detecting PSS, although it does depend on the examiner's skill and experience [4]. In this case, PSS was suspected based on ultrasonography; however, the location and number of shunts and the connected vessels could not be clarified due to visceral malposition. Furthermore, anatomic comprehension of other tortuous vascular branches was needed.

CT is an excellent tool for evaluating the morphology of

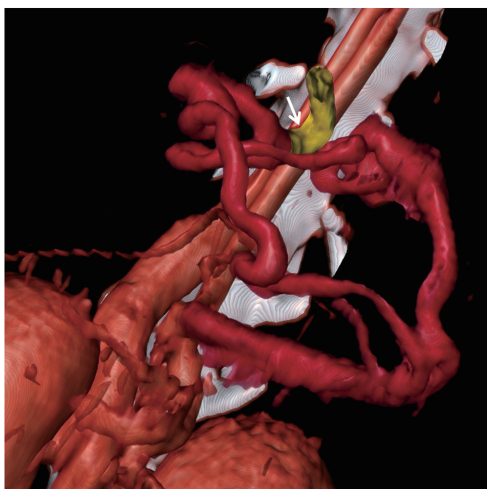


Fig. 2. Volume-rendered CT reconstruction of the dog viewed from a left ventral perspective. The portal branch (red) showed a serpentine course and entered the left hepatic vein (yellow).

anomalous vessels, as it provides images of the transverse plane without superimposition of structures and can be used to assess multiple complex anomalies using reconstructed three-dimensional images. CT was useful to not only anatomically discriminate the congenital malformations but also to create a treatment plan based on understanding the hemodynamic state among the 4 vascular anomalies in the dog. Surgical intervention was only necessary for the PSS classified as a single extrahepatic shunt, and other vascular abnormalities, such as azygos continuation of the CdVC, split CdVC and persistent left CrVC, should be avoided unnecessary surgical treatment for hemodynamic circulation.

In azygos continuation of the CdVC, the shunt provides a direct route for venous return to the heart, so that accidental ligation of the shunt can be fatal, as shown in previous case reported in the human literature [5]. One other point claiming our attention in this anomaly is thrombosis, which can occur due to slowing blood flow of the shunt [9, 10]. We could define the functional shunt between the azygos vein and renal CdVC and rule out thrombosis, shown as a filling defect, using CT angiography.

Split CdVC is the duplication of the pre renal and renal CdVC and has no clinical significance [16, 17, 20]. However, this anomaly added complexity to the abdominal vessel anatomy in this case.

During CT scanning, persistent left CrVC was found incidentally in the dog. Persistent left CrVC can be classified as a complete or incomplete type depending on whether distal portion of the left CrVC atrophies [1]. The incomplete type of this vessel can form a ring with the trachea and constrict the esophagus, leading to megaesophagus [14]. Moreover, the clinical significance of this malformation can be determined based on the structure it enters. This has no clinical significance when it enters the right atrium, unlike the case when it enters the left atrium. The present case was a complete type

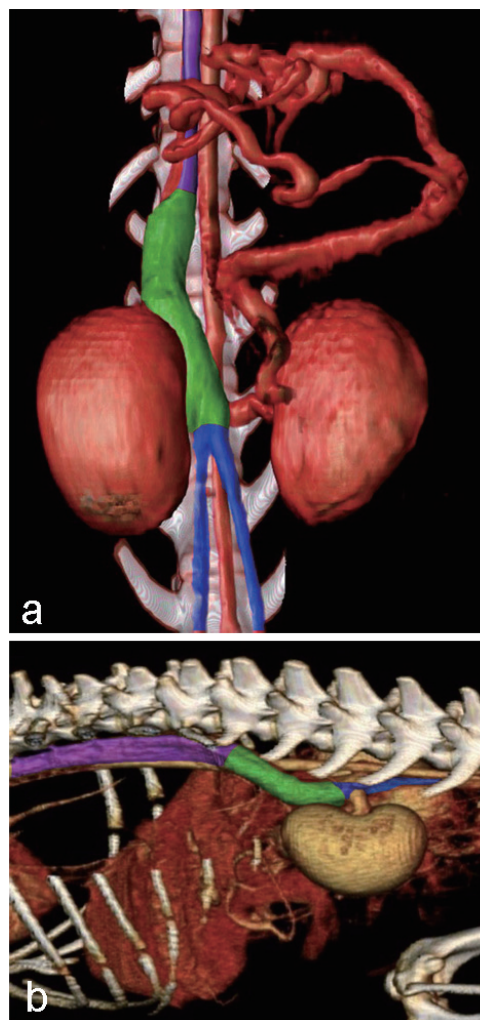


Fig. 3. Volume-rendered CT reconstruction of the dog viewed from a ventral (A) and lateral (B) perspective. Two separate branches of the pre renal caudal vena cava (blue) converged at the renal level and then cranial to this, a single caudal vena cava (arrowhead) connected to the azygos vein (purple) through the shunt (green) with the prehepatic caudal vena cava being absent.

of persistent left CrVC that entered the right atrium without obstructing other structures, such as the esophagus.

Coexistence of situs inversus, PSS and azygos continuation of the CdVC has been reported in 2 other dogs previously [10, 15]. Persistent left CrVC has been reported in association with cardiac defects or other types of thoracic vascular anomalies [1, 2, 6, 8, 11, 12, 19, 22]. A hypothesis concerning genetic factors related to these vascular anomalies has been postulated; however, there has been no case in which persistent left CrVC and abdominal visceral and vascular malformations were in synchrony.

A lot of different types of congenital vascular malformations can simultaneously occur, and the clinical significance

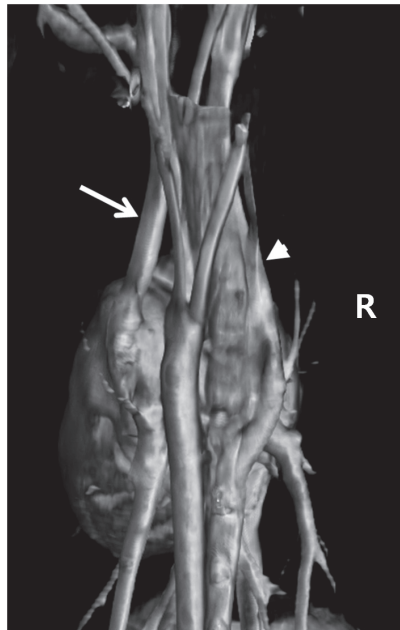


Fig. 4. Volume-rendered CT reconstruction of the dog viewed from a dorsal perspective. The complete type of left CrVC (long arrow) entered the right atrium along with the normal right cranial vena cava (arrowhead).

of each type may be different. Moreover, if the visceral position is reversed, it can add difficulty to understanding the characteristics of vascular anomalies. This dog had complicated malformations including situs inversus, PSS, azygos continuation of the CdVC, split CdVC and even persistent left CrVC. Using CT angiography, the anatomy and function of each anomaly could be evaluated in detail, and surgical intervention was successfully performed.

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