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Persistent right aortic arch with aberrant left subclavian artery originating from the patent ductus arteriosus in a dog: a case report

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Abstract

A 4-month-old intact male Sapsaree dog was referred due to a history of postprandial regurgitation following consumption of solid food. Thoracic radiography revealed focal leftward displacement of the thoracic trachea at T1 to T4 vertebrae levels. Barium contrast radiography revealed focal dilation of the cranial thoracic esophagus at the heart base level. Persistent right aortic arch (PRAA) with an aberrant left subclavian artery branching from the patent ductus arteriosus was diagnosed by computed tomography angiography (CTA). Although barium contrast radiography can presumptive diagnose PRAA, CTA should be considered for identifying additional vascular anomalies, specific types, and surgical planning.

Keywords: computed tomography angiography, vascular ring, patent ductus arteriosus, subclavian artery

Vascular ring anomalies are congenital malformation of great vessels and associated structures, resulting in encirclement and displacement of both the esophagus and trachea through formation of a complete or partial vascular ring [1,2].

In veterinary literature, nine types of vascular ring anomalies have been reported. The frequency of reports of dogs with vascular ring anomalies varies with the type of anomaly [3,4]. It has been documented that a persistent right aortic arch (PRAA) with a left ligamentum arteriosum contributes to 95% of clinical vascular ring anomalies in dogs [5]. In the presence of a left ligamentum arteriosum, compression of the thoracic trachea and esophagus occurs, forming a vascular ring comprised of permanent arch of the aorta and the ligamentum arteriosum [6]. This compression results in cranial esophageal dilation and regurgitation of solid food shortly after weaning [6]. Although the occurrence of vascular ring anomalies corresponding to remaining types is rare [3], identifying the specific type is crucial as surgical approach varies depending on the type.

There is a growing trend emphasizing the importance of computed tomography angiography (CTA) in confirming the precise type of vascular ring anomaly. However, reports on CTA for rare types of vascular ring anomalies are limited [3,4]. Thus, the purpose of this case report was to highlight the importance of using CTA in suspected PRAA cases by presenting a patient diagnosed with PRAA and an aberrant left subclavian artery originating from the patent ductus arteriosus (PDA).

A 4-month-old intact male Sapsaree weighing 2.3 kg was referred due to a history of postprandial regurgitation following consumption of solid food. The owner reported that the dog had manifested clinical signs of regurgitation after weaning since visiting this hospital one month before. The owner also reported that the dog was emaciated compared to other dogs of the littermate. Upon presentation, the dog was bright and alert. All vital parameters showed no abnormalities, and auscultation detected a normal rhythm. The remainder of the physical exam, complete blood count, and serum biochemistry were all unremarkable except for a mild anemia (hematocrit, 30.5%; reference interval, 35% to 55%).

Plain thoracic radiographs demonstrated a gas-filled dilatation of the cranial thoracic esophagus in the lateral view and a left-sided displacement of the thoracic trachea in the ventrodorsal view (Fig. 1A). Afterwards, a barium esophagram was conducted, revealing dilatation of the esophagus cranial to the base of the heart (Fig. 1B). Based on the dog's age of the onset, clinical signs, and radiographic findings, the presumptive diagnosis was PRAA. Other differential diagnoses included esophageal stricture, esophagitis, idiopathic megaesophagus, and radiolucent foreign body.

Accurate vascular anatomical structure was assessed using a 160-slice multidetector CT (Aquilion Lightning 160; Canon Medical Systems, Japan) under general anesthesia. The dog was premedicated with butorphanol (0.2 mg/kg, intravenous [IV] Butophan; Myungmoon Pharm, Korea) and midazolam (0.2 mg/kg, IV, Midazolam Inj.; Bukwang, Korea) and then induced with propofol (6 mg/kg, IV, Prepole MCT; Daewon Pharm, Korea) followed by isoflurane (Irfan; Hana Pharm, Korea) in oxygen (2.0 L/min) via endotracheal intubation. The dog was placed in a sternal recumbent position throughout the entire procedure. A helical scan was conducted for the whole body in cranial to caudal direction to ascertain the position of the bolus tracking site and perform CTA. Scanning parameters of pre-contrast and angiographic volume images were as follows: 120 kVp, 150 mAs, 0.75 seconds rotation time, and 0.5 mm thickness. Non-ionic iodine contrast medium (Omnipaque 300; GE Healthcare, Norway) and saline were administered using a dual-head power injector (Salinet; Medrad Inc., USA). A dose of 3 mL/kg, containing an iodine content of 300 mgI/mL, was administered at a rate of 1 mL/sec. Subsequently, a saline injection was administered at half the volume of the contrast, maintaining a fixed injection rate of 1 mL/sec. Evaluation of the CTA revealed the presence of a PRAA, extending paramedian on the right side of the thorax, which resulted in a leftward deviation of the trachea and constriction of the esophagus at the third intercostal space (Fig. 2A). Additionally, multiple other vascular anomalies were detected, including a PDA and aberrant left subclavian artery. At the level of the descending aorta, a duct with a maximum short-axis diameter of 2.3 mm demonstrating contrast enhancement connecting towards the main pulmonary artery was identified, confirming the presence of a PDA (Fig. 2B). Following this PDA structure, a small aberrant left subcla-

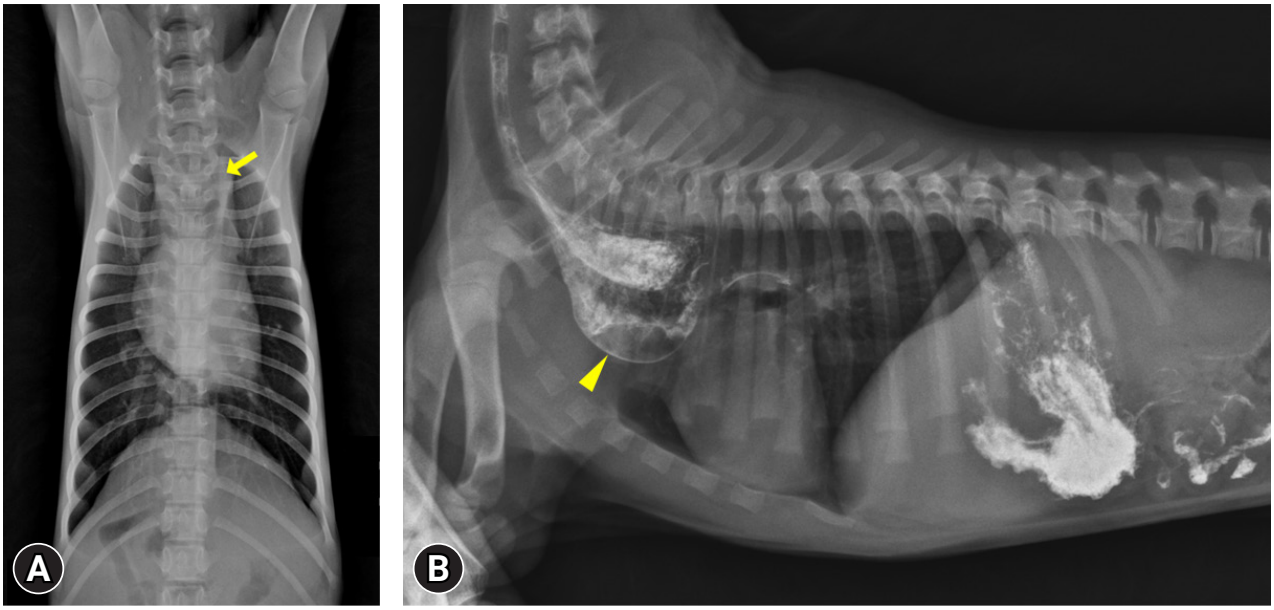

Fig. 1. Right lateral (A) radiograph obtained during barium esophagram and ventrodorsal (B) radiograph demonstrating focal dilation of the trachea (arrowhead) and leftward deviation of the trachea (arrow), respectively.

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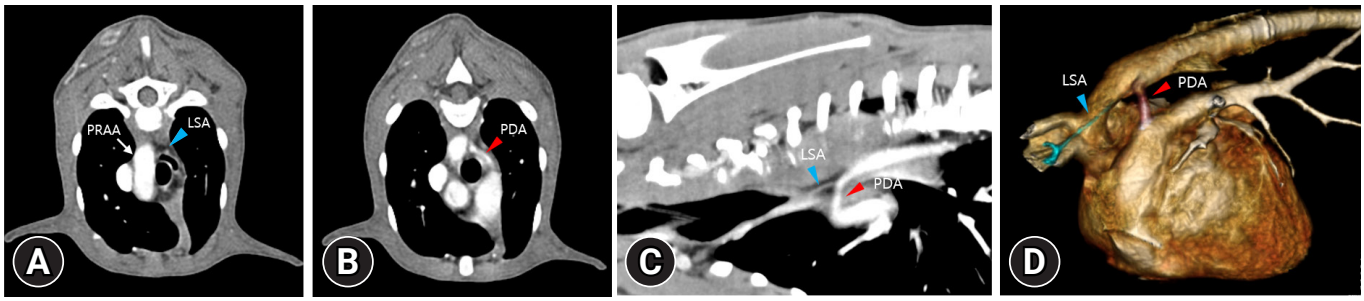

Fig. 2. Computed tomography (CT) angiography transverse images at the level of the proximal segment of the aberrant left subclavian artery (A) and the patent ductus arteriosus (PDA) (B). CT reconstruction (C, D) demonstrating persistent right aortic arch (PRAA) with aberrant left subclavian artery (blue arrowhead) originating from the PDA (red arrowhead). LSA, left subclavian artery.

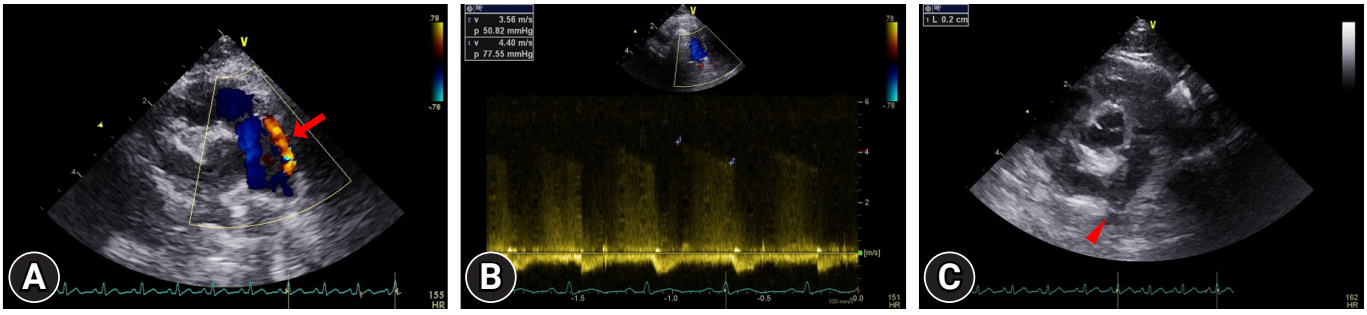

Fig. 3. Left parasternal short axis view of the cranial transverse heart base (A) and spectral Doppler imaging at the same level (B), showing a well-defined jet (red arrow) representing ductal flow within the pulmonary artery. Right parasternal short axis view of the heart base with pulmonary artery (C) showing a small sized duct (red arrowhead) at the level of the pulmonary artery.

vian artery arising from the cranial aspect of the duct was identified (Fig. 2C and D).

An echocardiogram confirmed the presence of a PDA with left-to-right shunting (Fig. 3A). Continuous ductal flow was measured at 3.98 m/s during systole and 3.03 m/s during diastole (Fig. 3B). On the right parasternal short axis view of the heart base with pulmonary artery, a small defect of 2 mm was seen at the level of the main pulmonary artery (Fig. 3C).

A left fourth intercostal thoracotomy was performed to ligate and transect the PDA and to assess whether the aberrant left subclavian artery caused esophageal compression. The left subclavian artery was observed to be extremely thin, suggesting that it might have a minimal impact on esophageal compression. As a result, the surgical procedure involved excising only the PDA while leaving the left subclavian artery intact.

The surgical procedure, administration of anesthesia, and subsequent recovery of the patient had no complications. For five days following the surgery, the patient did not experience a recurrence of clinical symptoms. Subsequently, the frequency of clinical symptoms gradually decreased. At the 7-month follow-up, the owner mentioned that no clinical symptoms were observed unless dietary modifications were made.

Vascular ring anomalies can result from abnormal embryologic development of aortic arches [1]. These anomalies can lead to structural alterations in the mature cardiovascular system [1]. Their consequences include the presence of abnormal vessels encircling the esophagus, the trachea, or both, leading to partial obstruction of these organs [1]. Nine types of vascular ring anomalies have been reported [3,4]. Type 1 corresponds to a PRAA with a left ligamentum arteriosum. This type has been reported to account for 95% of all vascular ring anomalies observed in dogs and cats [1,2,5]. In this case report, we described a type 8 vascular ring anomaly, which corresponds to right aortic arch with left subclavian branching from the PDA, a condition documented in only a few veterinary studies [6,7]. The case was accurately diagnosed through CTA, which confirmed the presence of a vascular structure with contrast enhancement connecting the aorta and pulmonary artery, indicating the existence of a PDA. A very thin aberrant subclavian artery branching from this structure was also identified.

A tentative diagnosis of a vascular ring anomaly is frequently established based on patient's medical history and findings

from clinical and radiographic examinations. Typically, the predominant clinical indicator of a vascular ring anomaly is regurgitation, manifesting in puppies or kittens during the transition to solid food at the weaning stage [1]. Affected animals frequently exhibit a slender physique compared to their littermates [1]. Some may experience dyspnea due to aspiration pneumonia [1,7]. Lateral imaging and contrast radiographs of such animals typically reveal constriction of the esophagus near the base of the heart, accompanied by dilation of the esophagus at the cranial of the heart. Ventrodorsal radiographs often show a leftward curvature of the trachea [6]. These distinctive radiographic observations are commonly associated with the presence of a PRAA [6,7]. As a result, additional diagnostic imaging of vascular ring anatomy before surgery is seldom undertaken [4]. However, despite PRAA representing about 95% of vascular ring anomalies [5], less common anomalies may coexist, which usually cannot be visualized by radiographic examinations [7].

In cases of vascular ring anomalies leading to esophageal compression and associated clinical signs, surgical recommendations generally involve dissection, ligation, and division of constricting vessels [8]. In the present case, PDA and aberrant left subclavian artery were two factors as potential causes of esophageal compression. Since the PDA and the subclavian artery were vascular structures, a different surgical plan was required compared to the more commonly occurring type of PRAA [5]. In the case of PDA, surgical correction was strongly considered [5]. With the left subclavian artery observed to exert minimal compression on the esophagus, surgeons decided to leave it intact [9]. As in the present case, considering that the surgical approach might vary depending on the type of vascular ring anomaly, it is crucial to obtain a precise understanding of the vascular anatomical structure through CTA before surgery to reduce the risk of life-threatening hemorrhage.

In conclusion, conventional methods such as patient history, clinical signs, barium esophagrams, and standard radiography for diagnosing PRAA can only provide limited information regarding differentiation of types. The process of conducting preoperative CTA plays a crucial role in accurately understanding the vascular anatomical structure before planning a surgical plan. Although radiography with clinical history can strongly suggest the presence of PRAA, CTA should be considered for identifying additional vascular anomalies, specific types, and surgical planning.

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References

1. Helphrey ML. Vascular ring anomalies in the dog. Vet Clin North Am Small Anim Pract 1979;9:207–218.
2. Ellison GW. Vascular ring anomalies in the dog and cat. Compend Contin Educ Pract Vet 1980;2:693–705.
3. Morgan KR, Bray JP. Current diagnostic tests, surgical treatments, and prognostic indicators for vascular ring anomalies in dogs. J Am Vet Med Assoc 2019;254:728–733.
4. Schorn C, Hildebrandt N, Schneider M, Schaub S. Anomalies of the aortic arch in dogs: evaluation with the use of multidetector computed tomography angiography and proposal of an extended classification scheme. BMC Vet Res 2021;17:387.
5. Buchanan JW. Thoracic surgery in the dog and cat. 3. Patent ductus arteriosus and persistent right aortic arch surgery in dogs. J Small Anim Pract 1968;9:409–428.
6. Buchanan JW. Tracheal signs and associated vascular anomalies in dogs with persistent right aortic arch. J Vet Intern Med 2004;18:510–514.

https://doi.org/10.14405/kjvr.20240015

7. Henjes CR, Nolte I, Wefstaedt P. Multidetector-row computed tomography of thoracic aortic anomalies in dogs and cats: patent ductus arteriosus and vascular rings. BMC Vet Res 2011;7:57.
8. Biasato I, Lanteri G, Guarda F, Capucchio MT, Marino F, Briguglio G, Macrì F. Unusual combination of multiple vascular anomalies in a German shepherd puppy with megaoesophagus. Anat Histol Embryol 2017;46:216–219.
9. Saunders AB, Winter RL, Griffin JF, Thieman Mankin KM, Miller MW. Surgical management of an aberrant left subclavian artery originating from a left patent ductus arteriosus in a dog with a right aortic arch and abnormal branching. J Vet Cardiol 2013;15:153–159.