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CASE REPORT

Diagnosis and Treatment of an Aberrant Right Subclavian Artery with Persistent Right Ligamentum Arteriosum in a Kitten

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ABSTRACT

A 5-month-old, male-intact, 2.1 kg, domestic shorthair cat was referred for investigation of persistent regurgitation following the ingestion of solid food. The regurgitation was observed soon after weaning. Episodes of respiratory distress and cyanosis were also present. Segmental dilation of the esophagus cranial to cardiac was observed on survey radiographs and esophagogram. A vascular ring anomaly, namely an aberrant right subclavian artery with a normal aortic arch, was confirmed on three-dimensional (3D) reconstructed CT images. More specifically, a Type 7 vascular ring anomaly comprising an aberrant right subclavian artery and a persistent right ligamentum arteriosum with a normal left aortic arch was diagnosed. The esophageal constriction was resolved by surgical transection of the fibrous ligament.

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INTRODUCTION

Vascular ring anomalies have been reported in dogs, cats, and even in wild carnivores (Yarim *et al*., 1999; Ketz *et al*., 2001; Lee *et al*., 2003; Yoon and Jeong, 2011). Vascular ring anomalies can be classified into seven types as follows: Type 1: a persistent right aortic arch and a persistent left ligamentum arteriosum. Type 2: a persistent right aortic arch and a persistent left subclavian artery. Type 3: a persistent right aortic arch and persistent left ligamentum arteriosum and a left subclavian artery. Type 4: a double aortic arch with a particular correlation in the morphology of its portions. Type 5: a normal left aortic arch and a persistent right ligamentum arteriosum. Type 6: a normal left aortic arch and a persistent subclavian artery. Type 7: a normal left aortic arch and a persistent right ligamentum arteriosum and a right subclavian artery (Helphrey, 1993).

A persistent right aortic arch is the most common and clinically significant form of vascular ring anomaly; it comprises 95% of all vascular ring anomalies. Numerous cases of persistent right aortic arches have been described; however, only a few cases of double aortic arches and right ligamentum arteriosum with a normal left aortic arch have been reported (Hurley *et al*., 1993). Since most abnormal vascular rings cause constriction and obstruction of the esophagus at the base of the heart, precise and rapid diagnosis and management of the patient is necessary.

Though survey or contrast radiographs can be used to screen for focal dilation cranial to cardiac, a congenital vascular ring can be detected more straightforwardly by computed tomography with helical CT and 3D image reconstruction. In this study, we describe the rare vascular ring anomaly of a normal left aortic arch, a persistent right ligamentum arteriosum, and a right subclavian artery confirmed by 3D-reconstructed CT images in a kitten.

History and clinical examinations: A 5-month-old, male-intact domestic shorthair cat weighing 2.1 kg was referred to the Animal Medical Center, Chonbuk National University, for the investigation of persistent regurgitation following the ingestion of solid food since weaning. Episodes of respiratory distress and cyanosis were also present. Mild dehydration (<5%) and depression were observed on physical examination. Neither a heart murmur nor abnormal lung sounds were found on thoracic auscultation. Rectal temperature was within the normal range (38.6°C), as were the results of routine hematological and biochemical analyses. On reviewing

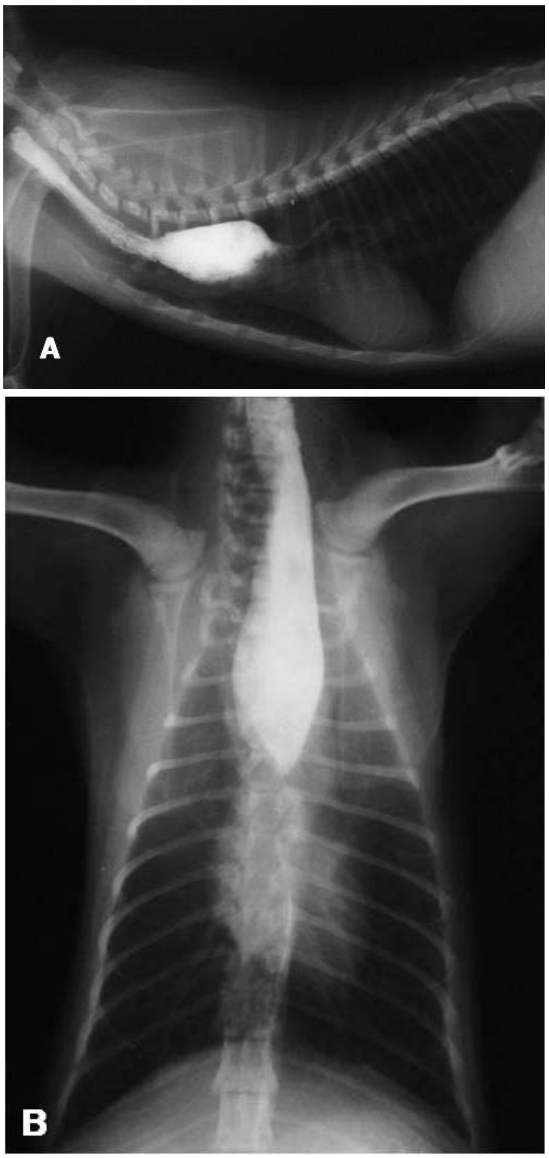

Fig. 1: Lateral (A) and ventrodorsal (B) esophagram of a kitten. The esophageal dilation cranial to the cardiac silhouette is identified on both views.

the lateral and ventrodorsal positive-contrast esophageal radiographs provided by the referring veterinarian, we hypothesized that the segmental esophageal dilation cranial to the heart base was possibly related to a vascular ring anomaly (Fig. 1).

Diagnosis and Treatment Response: We made a tentative diagnosis of a vascular ring anomaly and the patient was scheduled for a CT angiogram to further investigate if a vascular abnormality was present. Contrast-enhanced CT with a slice thickness of 3mm and a pitch of 1.5 revealed an abnormal branch of the right subclavian artery and normal left aortic arch. 3D-CT images allowed clear visualization of the anatomy of the vascular deformity (Fig. 2). The first large artery from the aortic arch, the brachiocephalic trunk dividing the right and left common carotid artery, and the second artery from the aortic arch, the left subclavian artery were normally branched. However, the third artery, namely the right subclavian artery, originated from the normal left aortic arch approximately 7 mm distal to the left subclavian artery. We, therefore, made a diagnosis of a vascular ring anomaly consisting of an aberrant right subclavian artery and a probable persistent right ligamentum arteriosum with a normal left aortic arch based on the CT findings.

The patient was premedicated with atropine sulfate (0.025 mg/kg, intravenously), and butorphanole (0.2 mg/kg intravenously). Then the cat had an induction with propofol (6 mg/kg intravenously) under 100% oxygen and intubation with an endotracheal tube. Cefazoline (20 mg/kg) was administered before and every 2 hours until the end of the surgical procedure. Anesthesia was maintained with 1.2-1.5% isoflurane with 100% oxygen at 1 L/min.

A left thoracotomy was performed at the fifth intercostal space. The left ligamentum arteriosum was found at the usual site between the aorta and pulmonary trunk above the base of the heart. A fibrous ligamentum, which we considered to be a persistent right ligamentum arteriosum, passed from the aorta, over the esophagus and trachea, and attached to the right pulmonary artery at the level of origin of the anomalous right subclavian artery on the caudal aortic arch. The esophagus was enclosed in the narrow space between the right pulmonary artery, the fibrous ligamentum, the aorta, and the underlying heart base. Endoesophageal insertion of a rigid probe revealed obstruction of the esophagus. Dissection of the fibrous ligamentum resolved the esophageal constriction immediately. We confirmed the patency of the esophagus by passing the probe through the narrowed region liberally. Surgical correction was successful without any difficulties.

Physiological vital signs were continuously monitored in post-operative care during operation. After surgical correction, the chest was closed with routine methods. The cat was given tramadol hydrochloride (3mg/kg intravenously) at the end of operation for postoperative analgesia. The patient recovered well from the thoracostomy.

DISCUSSION

Clinically, various vascular ring anomalies in companion animals are suspected on the basis of signalment, history, and physical examination results. Proof supporting the diagnosis can usually be obtained by plain and contrast radiography, as well as esophagoscopy. Dilation of the cranial thoracic esophagus observed on the lateral thoracic radiograph is a typical finding in animals with vascular ring anomalies (Hurley *et al*., 1993). Among the cases of vascular ring anomalies that have been reported in domestic cats, a persistent right aortic arch with left ligamentum arteriosum (Lee *et al*., 2003) is the most common abnormality observed, whereas a persistent left aortic arch with a right ligamentum arteriosum and a double aortic arch (Yarim *et al*., 1999) are rare anomalies.

Depending on the aortic arch formation, the seven types of vascular ring anomalies can be assigned to one of three groups. The first group is defined by a persistent right aortic arch; this group includes a persistent left ligamentum arteriosum (Type 1), a persistent left subclavian

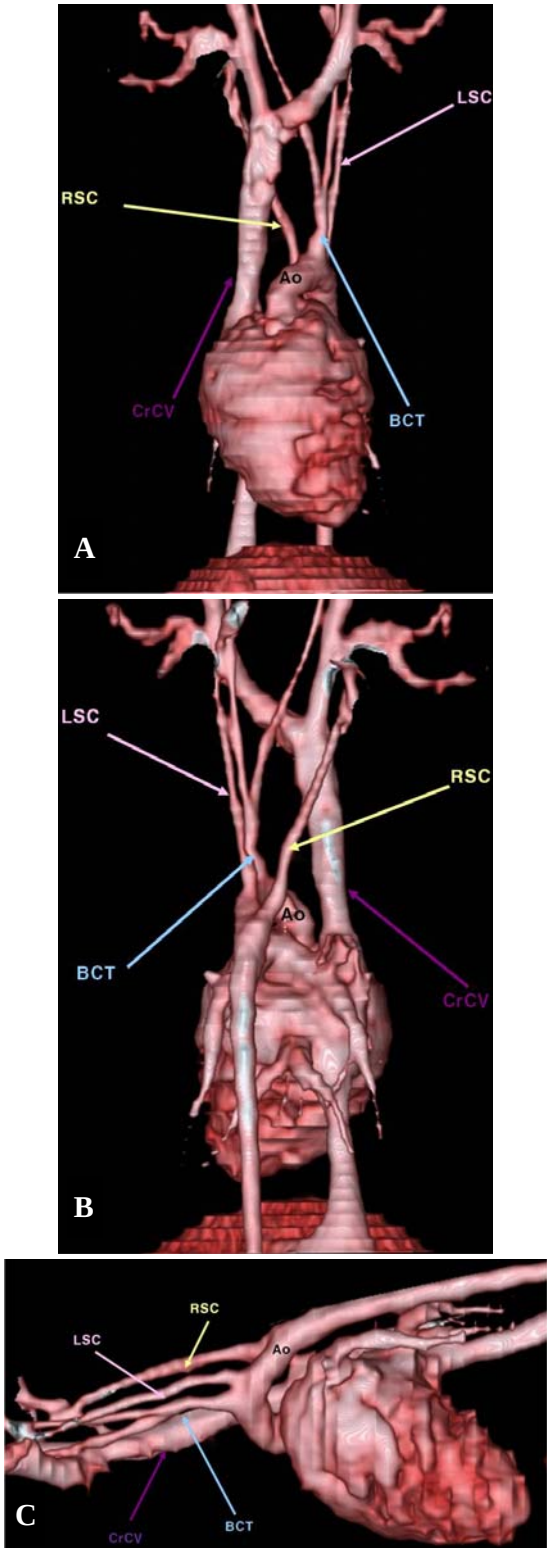

Fig. 2: Volume rendering 3-D reconstruction images of vascular ring anomaly with aberrant right subclavian artery and normal left aortic arch in a kitten. A) Ventral, B) Dorsal and C) Lateral view, respectively. The first large branch from the normal left aortic arch, the brachyocephalic trunk dividing the right and left common carotid artery, and the second branch from the aortic arch, the left subclavian artery, are normally developed. However, the third artery, namely the right subclavian artery, originated from the aortic arch approximately 7 mm distal to the left subclavian artery compatible with aberrant right subclavian artery. RSC=right subclavian artery; BCT= brachiocephalic trunk; LSC=left subclavian artery; Ao=aorta; CrCV=cranial vena cava.

artery (Type 2), and a persistent left ligamentum arteriosum and left subclavian artery (Type 3). The second group is defined by the presence of a double aortic arch with a particular correlation in the morphology of its portions (Type 4). The third group has a normal left aortic arch, and includes a persistent right ligamentum arteriosum (Type 5), a persistent subclavian artery (Type 6) and a persistent right ligamentum arteriosum and a right subclavian artery (Type 7) (Helphrey, 1993).

Though definitive diagnosis of a vascular anomaly and accurate determination of the vascular arrangement can be achieved by a combination of selective angiography and surgical investigation, nowadays, 3D-reconstructed CT images can be used to visualize the anatomy of the vascular abnormality without the need for invasive procedures such as selective angiography. Three dimensionally-reconstructed CT images have played an important role in diagnosing vascular abnormalities in human patients (Kondo *et al*., 2005).

To the best of our knowledge, there is no prior report of the use of 3D images to diagnose a type 7 vascular ring anomaly in a kitten in the veterinary literature. We diagnosed an aberrant right subclavian artery with a normal left aortic arch based on 3D-CT images. The right subclavian artery along with the bicarotid trunk normally originates from the brachycephalic trunk, the first large artery to arise from the aortic arch (Moon and Rowels, 1993). In our case, the origin of the major arteries from the aortic arch was anomalous, similar to the previous case report (McCnadlish *et al*., 1984). From the root of the aorta, the vessels originated in the following order: right and left common carotid artery from the brachycephalic trunk, left subclavian artery and then, approximately 7 mm further, the right subclavian artery running dorsally from the aorta. Even though the exact features of the thin ligamentum arteriosum associated with an abnormal vascular formation that causes esophageal constriction may not be clearly visible on 3D-CT images, a vascular deformity observed on 3D-CT images can indicate the possibility of an unusual vascular ring anomaly, such as a right subclavian artery and a normal left aortic arch with probable persistent right ligamentum arteriosum, rather than the typical vascular ring anomaly of a persistent right aortic arch with left ligamentum arteriosum. Moreover, the surgeon can use the 3D CT images in operation planning.

One limitation of our study is that we used 3D CT imaging, which cannot reveal a right ligamentum arteriosum because of its soft tissue component. Furthermore, although ligation of an aberrant subclavian artery is recommended because the artery may cause dorsal compression as it crosses the esophagus, we only performed transection of the right ligamentum arteriosum because no apparent constriction of the esophagus by the aberrant right subclavian artery was observed, similar to the recent report (Henjes *et al*., 2011).

Conclusion: The authors encountered a rare case of vascular ring anomaly in a kitten having a right subclavian artery and a persistent right ligamentum arteriosum with a normal left aortic arch leading to esophageal constriction associated with regurgitation and the vascular ring anomaly was confirmed by 3D-CT image. 3D-CT is considered to be an excellent diagnostic method to

confirm the vascular anomaly and classify the various types precisely in a suspected vascular ring anomaly patients as well as communicating with the patient owner and surgeons.

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