CASE REPORT

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Persistent right aortic arch in the cat: a case report from a late surgical approach

Persistência do arco aórtico direito em gato: relato de caso a partir de uma abordagem cirúrgica tardia

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ABSTRACT

Aortic arch anomalies can give rise to vascular rings, such as persistent right aortic arch (PRAA), a rare vascular anomaly in cats with significant health implications. Here, we report late surgical correction in a case of PRAA, an almost 12-month-old cat with the clinical syndrome of dysphagia and postprandial regurgitation. The patient was presented to the veterinary hospital at FMVZ-USP with a history of chronic regurgitation since puppyhood after weaning, with a significant worsening of the clinical condition 10 days ago. Computed tomography had a potential role in diagnosing and detecting complications of PRAA, allowing surgical planning. Approach via left thoracotomy and section of the arteriosus ligament resulted in the successful resolution of extrinsic esophageal compression due to PRAA with the restoration of normal swallowing of a dry diet by the cat and absence of esophageal sequelae on radiographic assessment in a six-month clinical follow-up.

Keywords: Feline. Vascular ring anomaly. Regurgitation. Computed tomography. Left intercostal thoracotomy.

RESUMO

Anomalias do arco aórtico podem dar origem a anéis vasculares, como o arco aórtico direito persistente (PRAA), uma anomalia vascular rara em gatos com implicações significativas para a saúde. Aqui relatamos a correção cirúrgica tardia em um caso de PRAA em gato de quase 12 meses de idade com quadro clínico de disfagia e regurgitação pós-prandial. O paciente deu entrada no hospital veterinário da FMVZ-USP com histórico de regurgitação crônica desde filhote após o desmame e piora importante do quadro clínico há 10 dias. A tomografia computadorizada teve um papel potencial no diagnóstico e detecção de complicações da PRAA, permitindo o planejamento cirúrgico. A abordagem por toracotomia esquerda e secção do ligamento arterioso resultou na resolução bem-sucedida da compressão extrínseca do esôfago pela PRAA com restauração da deglutição normal de dieta seca pelo gato e ausência de sequelas esofágicas na avaliação radiográfica em seis meses de acompanhamento clínico.

Palavras-chave: Felino. Anomalia do anel vascular. Regurgitação. Tomografia computadorizada. Toracotomia intercostal esquerda.

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Introduction

Vascular ring anomalies are congenital malformations of the aortic vasculature and its branches resulting in abnormal development of the embryonic aortic arches, leading to esophageal compression and dilation, and in addition, implying a significant potential risk for airway compression (Buchanan, 2004; Schorn et al., 2021). Together with patent ductus arteriosus (PDA), the persistent right aortic arch (PRAA) is among the central vascular anomalies in dogs and cats (Henjes et al., 2011; Hutton et al., 2015), although it is rarer in cats than in dogs, with literature limited to some reported clinical cases (Bascuñán et al., 2020; Plesman et al., 2011; Shannon et al., 2015).

Under normal conditions, where the aorta arises from the fourth left arch, the aorta and main pulmonary artery are on the left side of the trachea and esophagus. The right ductus arteriosus disappears before birth, the left ductus arteriosus closes postnatally, and the ligamentum arteriosus remains. PRAA arises with the development of the aorta from the fourth right embryonic aortic arch instead of the left, which entraps the esophagus as the ligamentum arteriosus develops and crosses the esophagus to connect the main pulmonary artery to the anomalous aorta. Animals typically show signs of postprandial regurgitation of solid foods soon after weaning. Clinical respiratory symptoms such as stridor, wheezing, and coughing may be seen when tracheal entrapment or aspiration pneumonia occurs. In some cases, the food content can be palpated in the cervical region near the entrance to the chest (Ellison, 2014; Monnet, 2017).

Esophageal dilatation cranial to the base of the heart on plain chest radiographs or esophagograms suggests the presence of vascular ring anomalies (Thrall, 2018). However, accurately delineating the vessel wall and providing comprehensive images in a three-dimensional perspective allows computed tomography (CT) to confirm the diagnostic suspicion (Schorn et al., 2021). CT imaging is still instrumental in the simultaneous assessment of airway obstructions and may have implications for management and prognosis (Henjes et al., 2011). Early diagnosis and surgical treatment of PRAA are recommended to minimize the risk of aspiration pneumonia and permanent impairment of esophageal function (Plesman et al., 2011; Shannon et al., 2015). There is limited peer-reviewed literature on the occurrence and short and long-term surgical outcomes of PRAA in cats. Here, we report a clinical presentation of a young adult cat with vascular ring anomaly associated with highlighting the diagnostic approach and the success of its surgical correction, even if late, with a six-month clinical follow-up evaluation after treatment.

Case Report

A shorthair mixed male cat, almost 12 months old, weighing 3.9 kg, was presented to the School of Veterinary Medicine and Animal Science of the University of São Paulo (FMVZ-USP) with a history of chronic intermittent regurgitation from the uptake of solid food and repeated episodes of aspiration pneumonia. Within six months, the animal had been diagnosed with PRAA by a veterinarian who guided clinical and dietary management with feeding in a bipedal position as the primary treatment. The cat could consume soft meals without regurgitating until recently before presentation when 10 days ago, it evolved into a regurgitation of all types of food and progressive weight loss. Physical examination showed a body condition score under ideal (4/9), no heart murmur on auscultation, and no abnormalities in complete blood count, serum biochemistry, arterial blood gas analysis, electrocardiography, and echocardiography were detected. A lateral survey radiographic of the thorax showed dilatation of the esophagus cranial to the base of the heart, filled with a large amount of heterogeneous content (food), and the trachea deviates ventrally, indicative of vascular ring anomaly (Figure 1). After the radiographic findings, the cat underwent a CT scan that confirmed the PRAA with a left arterial ligament measuring between 1.5 mm and 1.9 mm and ruled out other associated vascular anomalies (Figure 2). Subsequently, the animal was referred for surgery.
Anesthesia: Acepromazine 0.06 mg/kg via intramuscular (IM) and meperidine 3 mg/kg IM was performed to achieve conscious sedation; the patient received an initial bolus of propofol of 5 mg/kg intravenous (IV) and was maintained at an expiratory concentration of isoflurane at 1.0% and

expired fraction of oxygen (FiO2) at 48%, in an oxygen flow of 4.0 l/Kg/min. Even before the surgical incision, the patient underwent continuous remifentanil infusion 0.2 mg/kg IV and neuromuscular blockade with rocuronium 0.6 mg/kg IV. Preemptive analgesia was considered to reduce potential complications associated with surgical pain. **Surgery:** A surgical approach was performed via a left intercostal thoracotomy in the 4th space, which consisted of retraction of the left vagus nerve and location of the arteriosus ligament that promoted esophageal constriction (Figure 3). Resection of the arteriosus ligament was performed with a ligature using 3-0 nylon thread, and the esophagus was observed to dilate, and small fibrous bands restricting the esophagus were resected. Immediately after ligation, an esophageal tube was inserted orally, and progression was observed without difficulty to the region anterior to the base of the heart, confirming a patent esophagus. The chest cavity and transected areas were inspected for bleeding signs. Routine chest wall reconstruction was performed using 2-0 nylon thread with three simple separated stitches and an approximation of the muscle layers (serratus ventral, scalene, and latissimus dorsi) using simple continuous suture with absorbable 3-0 poliglecaprone thread and skin suturing using single, separated stitches with 4-0 nylon thread. After the surgical success and uneventful recovery, the patient did not need to remain in the intensive care unit and was discharged on the same day, with instructions for a soft and pasty diet feeding in an elevated position to provide daily basal energy needs and nursing care. An apparent reduction in esophageal volume was observed on a control radiograph 10 days after treatment, with a favorable clinical evolution of the patient (Figure 4). During subsequent clinical follow-up six months after surgery, the cat restored normal swallowing of a dry diet and general well-being, confirming the absence of esophageal sequelae on control radiographs.

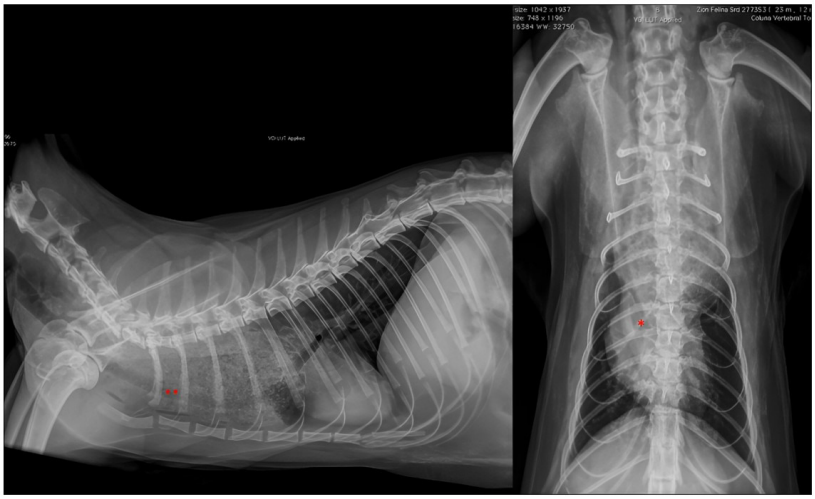

Figure 1 – Lateral and ventrodorsal survey thoracic radiographs of a cat show dilatation of the esophagus cranial to the base of the heart, filled with a large amount of heterogeneous content (food), ventral (**) and laterally to the right (*) displacement of the trachea. Diagnostic Imaging Service – FMVZ-USP.

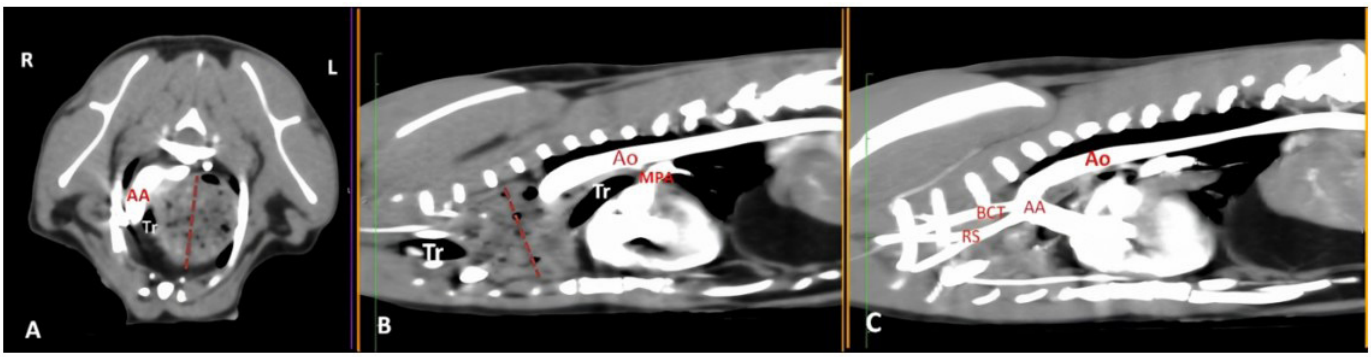

Figure 2 – **(A)** Post-contrast transverse CT image of the cranial mediastinum shows dilatation of the esophagus (dashed line) filled with a large amount of heterogeneous content (food) and gas. The aortic arch is on the right side. The trachea (Tr) deviates ventral and laterally to the right. **(B)** The Sagittal reconstructed CT image shows the location of the esophageal stricture between the aorta and pulmonary trunk (MPA). **(C)** MIP sagittal reconstructed CT image shows the absence of other vessel abnormalities. Ao: aorta; AA: aortic arch; BCT: brachiocephalic trunk; RS: right subclavian; MPA: main pulmonary artery; Tr: trachea.

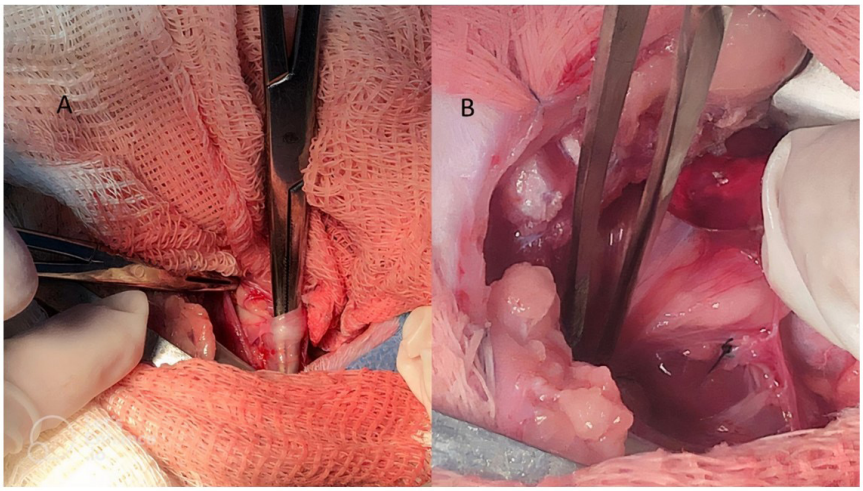

Figure 3 – Intraoperative image after access via left intercostal thoracotomy in 4th intercostal space. **(A)** The location of the ligamentum arteriosus is demonstrated in the hemostatic forceps. **(B)** Appearance after ligation and section of the ligamentum arteriosus. Small Animal Surgery Service – FMVZ- USP.

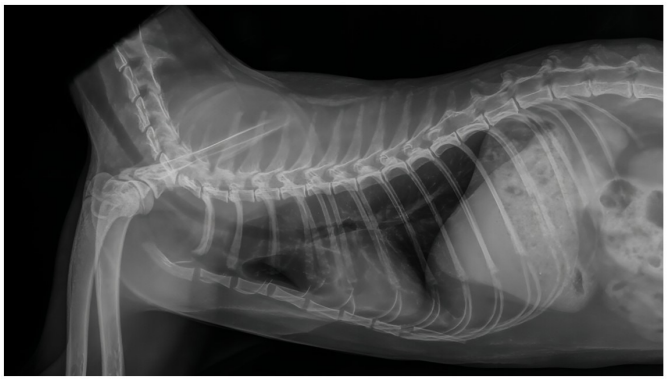

Figure 4 – Lateral thoracic radiography taken 10 days after surgery showed reduced esophageal dilation, filled with a small amount of cranial gas to the heart. The tracheal path was normal. Diagnostic Imaging Service – FMVZ-USP.

Discussion

The authors describe the clinical relevance of late surgical correction of PRAA in a shorthair mixed male cat, almost 12 months old at the time of presentation, and a favorable short-term course and outcome in a six-month clinical follow-up. Vascular rings encompass branching aortic arch abnormalities that can result in varying degrees of esophageal and airway compression (Henjes et al., 2011). The PRAA is one of the dogs' most common congenital vascular defects, where Labrador Retrievers, German Shepherds, and Irish Setters appear to be most at risk (Schorn et al., 2021). Although well-documented in dogs, vascular anomalies are considered uncommon in cats. They are still rarely diagnosed in adult cats (Bascuñán et al., 2020), which highlights the contribution of this case report to the scope of feline medicine practices. In the literature, vascular anomalies in cats have not been described as hereditary and associated with racial predisposition, as suggested in dogs (Philipp et al., 2011). Even though Persian and Siamese cats are more frequently reported (Monnet, 2017), the patient in question is a mixed breed.

From 1960 to 2020, there were only 25 reports described, including case series highlighting diagnostic and therapeutic approaches (Bascuñán et al., 2020; Berry et al., 1984; Henjes et al., 2011; Plesman et al., 2011; Shannon et al., 2015; Tidholm et al., 2015; Tremolada et al., 2013). The most extensive case series includes only 20 cats from different academic institutions, with PRAA representing 85% of cases (Bascuñán et al., 2020). Other anomalies described have a double aortic arch (Yarim et al., 1999) and a left aortic arch with right arterial ligament (McCandlish et al., 1984), in addition to PRAA associated with coarctation of the aorta at the level of the left arterial ligament (White et al., 2003) or the cranial vena cava (Wheaton et al., 1984). There is still no data describing the prevalence of PRAA in cats.

The presentation of clinical signs at a young age is expected due to the congenital etiology of the disease. The PRAA reflects on upper gastrointestinal tract clinical signs precisely because of the esophagus constriction at the base of the heart. The degree of esophageal compression is decisive in the clinical presentation, ranging from postprandial regurgitation after weaning and introducing a dry diet to puppies to respiratory distress (Buchanan, 2004). In this study, although a low body score and aspiration pneumonia were not observed at the time of presentation of the cat, these findings are often present. They are associated with mortality rates (Morgan & Bray, 2019). This case may, therefore, suggest that the absence of aspiration pneumonia and low body score is no objective evidence to rule out the disease in cats, even if regurgitation is not clinically significant until after the animals are fully grown.

In this case report, lateral and ventrodorsal survey thoracic radiographs showed esophageal constriction at the heart base, precordial esophageal dilation, ventral and laterally to the right displacement of the trachea, corroborating constant findings in previous studies (Thrall, 2018). While the radiographic images, together with the clinical history, were sufficient to indicate a suspicion of esophageal compression due to vascular ring anomaly in the cat, CT allowed an accurate localization of the abnormality, ruling out the coexistence of congenital variants that could negatively affect the surgical outcome and prognosis. Indeed, no assumptions can be made about the precise nature of vascular anomalies in dogs and cats, and advanced diagnostic imaging techniques such as CT are strongly encouraged before surgical approach to increase optimal patient safety and chances of successful therapeutic (Morgan & Bray, 2019; Plesman et al., 2011; Schorn et al., 2021), as recommended by current human medicine guidelines (Etesami et al., 2014).

Schorn et al. (2021) recently proposed an expanded classification scheme of dogs' traditionally described types of aortic arch anomalies by identifying at least two other types by CT. They showed that less frequent irregularities, not visualized by radiographic examinations or surgical exploration, can coexist. Furthermore, some vascular ring anomalies, such as the double aortic arch, are treated using a right intercostal approach (Henjes et al., 2011; White et al., 2003). Du Plessis et al. (2006) reported a dog's death with a presumptive PRAA diagnosis on radiographic examination and undergoing a left intercostal thoracotomy. The authors identified a double aortic arch at necropsy. Advanced imaging is vital in assessing and managing vascular ring anomalies, so the optimal surgical approach depends on the precise diagnosis. It is known that other vascular ring anomalies can cause esophageal constriction, and PRAA is not confirmed in the radiographic examination. Advanced imaging, such as CT, is available in veterinary medicine to diagnose vascular ring anomalies and should be discussed with the owner to help achieve the best results. So, knowing this, in this case, the professional team and the cat's owner prioritized the benefit of the cat's health.

PRAA does not remit spontaneously, and conservative therapy is associated with a poor long-term prognosis. Clinical treatment in a bipedal position proved purely palliative and inadequate in this case, as the dilation and regurgitation persisted, and the patient presented clinical worsening after a few months. The treatment of choice is surgical ligation and resection of the abnormal ligament. According to the classic technique described for the surgical approach of PRAA in dogs and cats (Ellison, 2014; Monnet, 2017), in this study, left intercostal thoracotomy was used and provided the necessary visibility for resection of arteriosus ligament and release of the trapped esophagus, in addition to allowing the reduction of periesophageal fibrosis. Available evidence in dogs supports that residual esophageal dilatation is not infrequently observed, and many of these animals require continued treatment and assistance through high-wet diet feeding (Morgan & Bray, 2019). Although the prognosis is reserved for the return of normal esophageal function and the expected risk of aspiration pneumonia, about 90% of animals that survive more than two months after surgery will have a good or excellent improvement in long-term quality of life. A worse prognosis can be expected for older animals (Krebs et al., 2014; Muldoon et al., 1997). Although potential surgical complications associated with thoracotomy, such as pulmonary dysfunction, infection, and seroma, in addition to pain, may occur (Plesman et al., 2011), in the present case, there were no complications or intercurrences associated with the traditional surgical technique and the patient's clinical evolution was favorable, even though it was an adult animal with an evolutionary disease.

To the authors' knowledge, data from controlled clinical follow-up studies showing long-term surgical outcomes and prognostic indicators of PRAA surgery in cats are lacking. Bascuñán et al. (2020) recently reported persistent clinical signs in 69% of cats after PRAA surgery, and radiographic evidence of megaesophagus persisted in 31% at a median clinical follow-up of 275 days. Although the persistence of clinical signs is expected even after a successful surgical procedure, the surgery was curative in this study. It led to the complete remission of dysphagic syndrome in the cat. The patient is alive at the time of this publication in a six-month clinical follow-up, with no clinical and radiographic evidence of esophageal sequelae. Finally, the tutor reports an excellent short-term therapeutic result. The cat gained weight and no longer regurgitated at home after hospital discharge.

Conclusion

Although rare, PRAA should be considered in cats with a history of regurgitation, regardless of age at presentation. CT allows a definitive diagnosis of PRAA and makes surgical planning more accurate and safer. Despite the potential risk of permanent dilation of the esophagus and persistence of clinical signs, surgical correction in an adult shorthair mixed male cat, almost 12 months old, with PRAA was successfully performed, provided the clinical management was adequate beforehand.

Conflict of Interest

The authors declare no conflicts of interest.

Ethics Statement

The hospital procedures adopted for the clinical management of this case were performed following the care standards of the FMVZ-USP Veterinary Hospital. A verbally informed consent for publication of this case report, including accompanying images, was obtained from the animal's owner.

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