Journal of Veterinary Cardiology (2019) **23**, 15—20

Journal of Veterinary Cardiology
ESVC

www.elsevier.com/locate/jvc

Case Report

Surgical resection of a left auricular aneurysm in a dog☆

Desiree Rosselli, DVM*, Chad Schmiedt, DVM, Shannon Kirejczyk, DVM, MPH, Kaori Sakamoto, DVM, PhD, Amelia Sinkin, VMD, Gregg Rapoport, DVM

Department of Small Animal Medicine and Surgery, University of Georgia College of Veterinary Medicine, 2200 College Station Road, Athens, GA 30602, United States

Received 7 June 2018; received in revised form 12 December 2018; accepted 14 December 2018

KEYWORDS
Auriculectomy;
Aneurysmectomy;
Canine

Abstract Aneurysmal dilation of the atrial appendage (auricle) is rare in humans and dogs. Congenital and acquired etiologies are hypothesized. Although right auricular aneurysm has been described in dogs, this is the first case report of an aneurysm of the left auricle of a dog with an intact pericardium. In humans, because complications of arrhythmia and thromboembolic disease have been reported, surgical resection of left auricular aneurysm is recommended. This report describes the successful surgical resection of a left auricular aneurysm in a dog, including a one-year follow up. Surgical resection can be considered in dogs with auricular aneurysm.

A 9-year-old male neutered toy poodle was referred for evaluation of a change in cardiac murmur intensity. A left apical systolic murmur was noted 6 months before presentation; at the time, enalapril (0.5 mg/kg PO q 12 h) was prescribed. One week before presentation, the

☆ A unique aspect of the Journal of Veterinary Cardiology is the emphasis of additional web-based images permitting the detailing of procedures and diagnostics. These images can be viewed (by those readers with subscription access) by going to http://www.sciencedirect.com/science/journal/17602734. The issue to be viewed is clicked and the available PDF and image downloading is available via the Summary Plus link. The supplementary material for a given article appears at the end of the page. Downloading the videos may take several minutes. Readers will require at least Quicktime 7 (available free at http://www.apple.com/quicktime/download/) to enjoy the content. Another means to view the material is to go to http://www.doi.org and enter the doi number unique to this paper which is indicated at the end of the manuscript.

* Corresponding author.
E-mail address: ddrosselli@gmail.com (D. Rosselli).

https://doi.org/10.1016/j.jvc.2018.12.004
1760-2734/

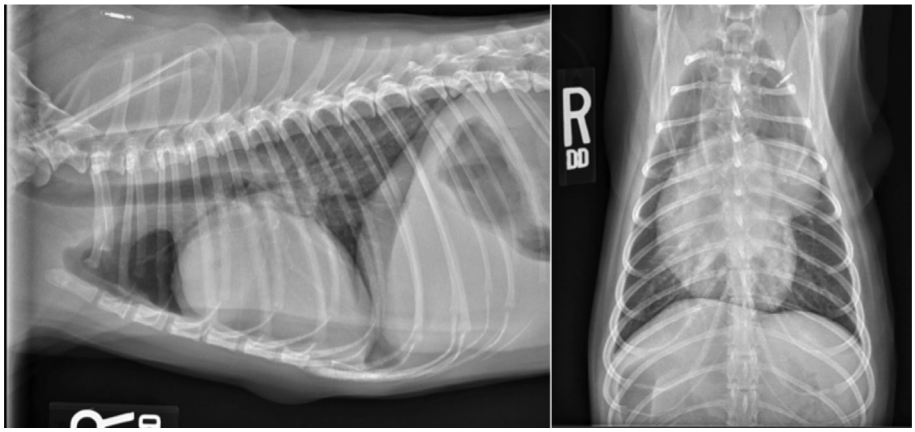

Fig. 1 Right lateral and ventrodorsal thoracic radiographs of a 9-year-old toy poodle with a smoothly marginated soft tissue opacity silhouetting with the left cranial margin of the cardiac silhouette.

primary care veterinarian diagnosed pulmonary crackles and a murmur progression from a grade III/VI to a grade V/VI. The patient was prescribed pimobendan (0.25 mg/kg PO q 12 h) and furosemide (2.5 mg/kg PO q 12 h), in addition to enalapril. The patient's attitude and appetite improved with therapy.

On examination, the patient was bright and alert with a body weight of 5.3 kg and a body condition score of 5/9. Heart rate was 90 beats/minute with a grade VI/VI left apical systolic murmur. Respiratory rate was 26 breaths/minute; the patient was eupneic with normal lung sounds. A Doppler blood pressure was 120 mmHg. The oral mucous membranes were pink and moist with a capillary refill time of less than 2 s.

The concern for historical signs associated with congestive heart failure prompted a more thorough cardiac evaluation. Thoracic radiographs (Fig. 1) showed a soft tissue opacity silhouetting with the left cranial margin of the cardiac silhouette. Differential diagnosis included pericardial mass, pericardial cyst, pericardial herniation, left atrial appendage (auricle) dilation, or pulmonary soft tissue mass.

Echocardiography (Fig. 2) revealed aneurysmal dilation of the left auricle and myxomatous valve disease (classified as American College of Veterinary Internal Medicine (ACVIM) stage C based on previous response to diuretic therapy) including moderate-to-severe mitral and mild tricuspid regurgitation, mild dilation of the body of the left atrium (ratio of the left atrial dimension to the aortic annulus dimension [LA:Ao] 1.62 (range normal LA:Ao $<$1.6 [1,2]) and moderate left ventricular dilation (normalized diastolic left ventricular internal dimension 2.1) (range 1.27—1.85 [3]).

Surgical removal of the aneurysm was recommended because of the risk of arrhythmia, thromboembolism, or rupture. Preanesthetic blood panel showed a normal hemogram and leukogram; the platelet count was 204,000/μL (range 235,000—694,000/μL), with a mild elevation in mean platelet volume at 11.3 fL (range 6.1—10.1 fL). Serum chemistry abnormalities included mild hypochloremia at 102 mmol/L (range 105—123 mmol/L), hypercholesterolemia at 268 mg/dL (range 124—264 mg/dL), hyperalbuminemia at 4.1 g/dL (range 2.2—3.9 g/dL), and elevated alkaline phosphatase activity at 154 U/L (range 11—131 U/L).

Two days after diagnosis, the patient presented for surgery. Blood typing and crossmatching were performed, and clotting times (prothrombin time and partial thromboplastin time) were within reference intervals. General anesthesia was induced, and the patient was positioned in right lateral recumbency. The left lateral thorax was prepared for aseptic surgery. A standard left fifth intercostal thoracotomy was performed. The pericardium was incised and temporarily sutured to the body wall to gain access to the left auricle (Fig. 3A). The pericardium was intact but thin over the area of the aneurysm. The left auricle was immobilized and clamped with a tangential vascular clamp at the level where it joined the left atrium. The aneurysm was sharply excised. The tissue edges were opposed distal to the clamp with three horizontal mattress sutures followed by a double oversew continuous pattern using 3-0 polydioxanone.[a] The clamp was temporarily opened to place an additional suture over a small area of hemorrhage; otherwise, the surgical site had no leakage or hemorrhage (Fig. 3B). Thoracic lavage was performed with sterile saline. The temporary pericardial stay sutures were removed. A

[a] Ethicon, Ethicon Inc., Somerville, New Jersey, USA.

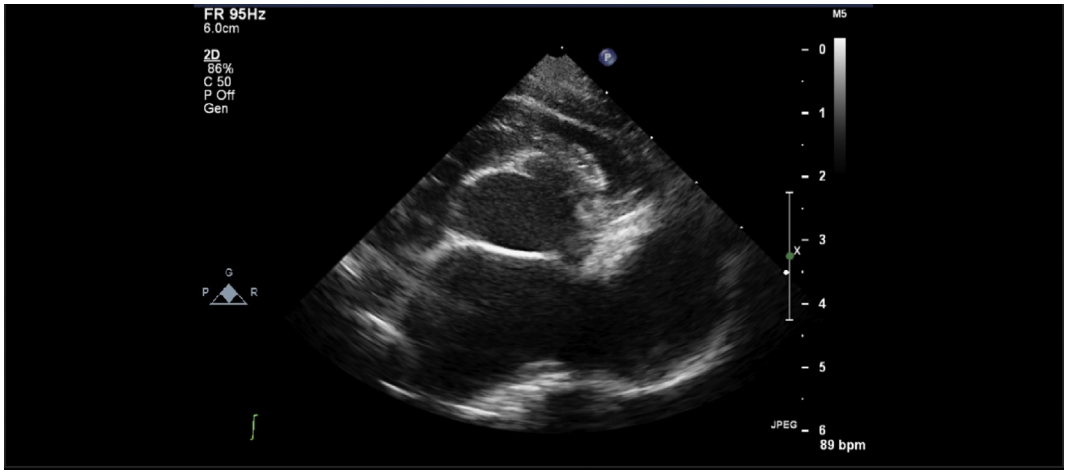

Fig. 2 Right parasternal short-axis echocardiographic view showing moderate dilation of the left atrial body and severe dilation of the left auricle, with the left auricle exceeding the size of the body of the left atrium. The pericardium is normal in appearance.

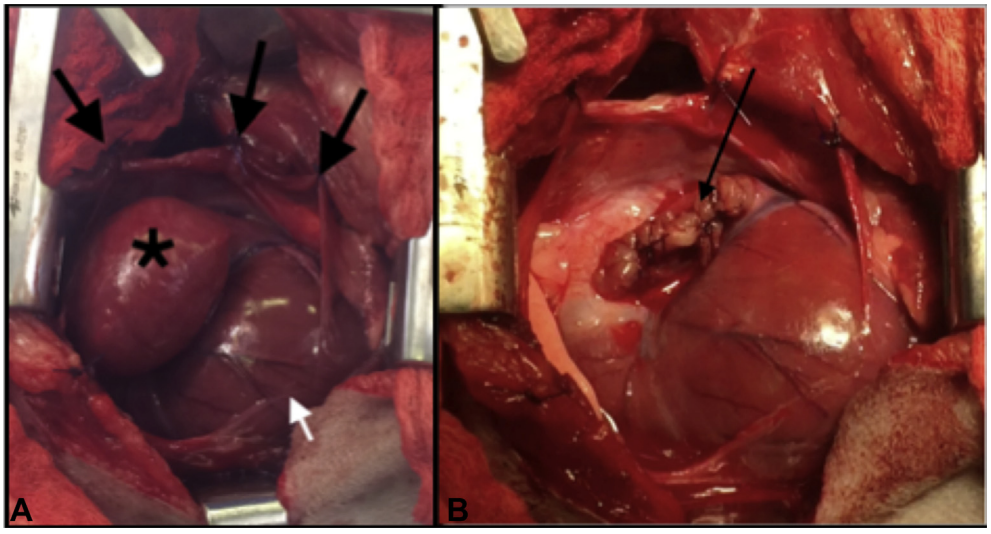

Fig. 3 A) Intraoperative photograph of an aneurysm of the left auricle of a dog. For orientation, cranial is to the left of the image and caudal is to the right of the image. The black arrows denote where the pericardium has been temporarily tacked to the body wall for exposure of the aneurysm, and the aneurysm is marked with an asterisk. The white arrow points to the cut surface of the pericardium (overlying the left ventricle). (B) Intraoperative photograph after resection of the left auricular aneurysm in the dog. The black arrow points to the double oversew suturing across the area of resection of the aneurysm from the left atrium.

thoracostomy tube[b] was placed and secured with 2-0 nylon[a]. Routine layered closure of the thoracotomy was performed using 2-0 polydioxanone[a] circumcostal sutures, 3-0 polydioxanone[a] for muscle apposition, and 3-0 poliglecaprone 25[a] for subcutaneous closure. Skin staples and a soft-padded chest wrap were placed.

[b] Argyle Trochar Catheter, Covidien, Mansfield, Massachusetts, USA.

The resected portion of the left auricle was submitted for histopathology. Grossly, the formalin-fixed left auricular tissue was thin and almost translucent. The epicardial surface was slightly roughened. The histopathology showed multifocal thinning of the left auricular wall and fibrous connective tissue within the epicardium (Fig. 4). The epicardium was multifocally thickened by short, papillary fronds composed of a core of fibrovascular tissue lined by hypertrophied

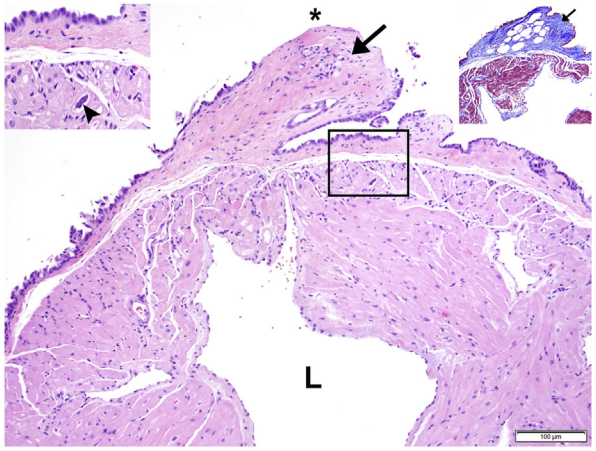

Fig. 4 Cross-section through the wall of the resected left auricular aneurysm. The myocardium is multifocally thin and short papillary fronds (mesothelial papillary hyperplasia) project into the pericardial space (*). The mesothelial papillary hyperplasia and subepicardial fibrosis are highlighted in blue on the Masson's trichrome stain (right corner inset). L = left auricular lumen, H&E stain, original magnification = 100×.

mesothelial cells (mesothelial papillary hyperplasia). The subepicardium was also multifocally expanded by interstitial collagen (fibrosis). Subepicardial myofibers exhibited vacuolation and variation in myofiber diameter (anisocytosis), with occasional myocyte and/or nuclear enlargement (karyomegaly). The histologic diagnosis was mild, multifocal, chronic myofiber degeneration, with subepicardial fibrosis and mesothelial papillary hyperplasia. There was no evidence of neoplasia.

Immediately after surgery, there were no signs of congestive heart failure or cardiac arrhythmias. The patient was discharged from the hospital three days after surgery and was prescribed clopidogrel for thrombotic prophylaxis (3.5 mg/kg PO q 24 h) and buprenorphine (0.02 mg/kg buccally q 8 h) for analgesia. Echocardiogram immediately after surgery and two weeks after surgery were similar and showed absence of the left auricle, with no visible thrombi within the body of the left atrium; LA:Ao 1.62.

During eleven months of the follow up, the patient was eating and drinking well at home, with a normal respiratory pattern and no episodes of exercise intolerance. Four months after surgery, echocardiogram showed similar moderate mitral valve thickening and severe prolapse and regurgitation; there was severe left atrial (LA:Ao 2.0) (range normal LA:Ao <1.6 [1,2]) and left ventricular dilation; there was mild pulmonary arterial hypertension (estimated systolic pulmonary artery pressure 45 mmHg) (range normal 25 mmHg, mild <50 mmHg, moderate 51–74 mmHg, severe >75 mmHg [4]). Clopidogrel was discontinued and furosemide was increased to 2.5 mg/kg three times daily. At eleven months after surgery, echocardiogram was static. Thoracic radiographs at both four and eleven months after surgery (Fig. 5) showed no evidence of pulmonary edema. Serum renal chemistry values were normal. A collapse episode at home eleven months after surgery prompted neurologic evaluation, and an abnormality was localized to the left prosencephalon or peripheral vestibular system. Magnetic resonance imaging was declined, and the case was lost to follow up.

Fig. 5 Right lateral and ventrodorsal thoracic radiographs of a dog eleven months after surgical resection of an aneurysm of the left auricle. There is mild left atrial and ventricular enlargement; the site of previous left auriculectomy is indistinct. The pulmonary parenchyma is normal.

Discussion

An aneurysm of an auricle is an abnormal ballooning of part of the wall of the auricle [5]. In veterinary species, aneurysms of the right auricle have been described. In cattle, two proposed etiologies for right atrial aneurysm exist; those that communicate with the atrial lumen are thought to be caused by a primary weakness within the atrial wall, whereas those with no atrial communication might be a sequela of systemic hypertension affecting intramural coronary arteries within pectinate muscles [6]. Three dogs have been reported in the veterinary literature with dilation of the right auricle [7,8]. For one dog, acute death occurred, and a diagnosis of right auricular aneurysm was confirmed on post mortem examination [7]. One dog died of seizures, and definitive diagnosis was not reached [8]. The third dog did not have a true aneurysm; rather, auricular herniation through a pericardial defect was diagnosed at surgery [8]. There are two additional case reports of dogs with herniation of the left auricle through a pericardial defect [9,10]. Our case had no pericardial defect on echocardiographic images. This was confirmed surgically by an intact, albeit thin, pericardium over the auricle. Although we did not obtain a piece of the pericardium for histopathology, the continuity of the pericardium in our dog suggests that the etiology is distinct from herniation through a pericardial defect. To the authors' knowledge, there have been no reports in the veterinary literature of left auricular aneurysms in dogs.

In humans, left auricular aneurysms are rare; they are most frequently congenital [11]. The exact pathogenesis is poorly understood but is thought to be due to weakness of the appendage wall [12]. In the canine patient, we report, here, that a congenital focal weakness of the left auricular wall is possible. Histopathologic changes were similar to those reported in humans: thinning and atrophy of the myocardium and replacement with fibrous tissue [5,11,13]. However, an acquired weakness secondary to chronic mitral regurgitation is also possible [14].

For humans, even asymptomatic patients, surgical resection is recommended due to potentially fatal complications including arrhythmias, embolic disease, and congestive heart failure [11,12,15]. In humans, various surgical approaches are described, including open or minimally invasive techniques, and those with and without cardiopulmonary bypass [5,12,13,16,17]. Although a minimally invasive approach has been described experimentally in normal dogs [18], we chose an open approach for this dog due to the small size of the patient as well as the risk for significant hemorrhage and the improved access to clamp and resect the potentially fragile aneurysm. A clamp application and oversew technique was used rather than the use of staplers or traction necessary for endoloop ligation, because of the thin walls of the aneurysm [16]. We used a polydioxanone suture material in our case; however, non-absorbable suture materials are more standard for use in cardiac surgery. Intraoperative transesophageal echocardiography may have been useful in our case to ensure no pulmonary vein impingement during aneurysm resection [17].

We recommended surgical excision because of the risk of arrhythmia, thromboembolism, or rupture of the aneurysm. An argument can be made for non-surgical management of auricular aneurysm in dogs, as there are potential complications associated with surgical excision, such as hemorrhage or arrhythmias during surgery. In addition, the left auricle in dogs is thought to have important reservoir functions to prevent elevation in left atrial pressure [19]. Experimentally, left auricular exclusion in dogs showed a significant increase in early diastolic transmitral flow velocity but no significant changes in left atrial pressure, left ventricular volume, and stroke volume. The long term effects of left auriculectomy are unknown [20]. Therefore, removal of the dilated left auricle could predispose a patient with mitral insufficiency to elevated left atrial pressures and left-sided congestive heart failure. Signs of congestive heart failure were not observed in our patient after surgery; however, our case did not have evidence of arrhythmia or thromboembolic disease at diagnosis, and these potential sequelae to aneurysm could be monitored for and potentially treated medically if they occurred, without the need for surgical intervention. The possibility for aneurysm rupture was the most compelling reason for recommending surgery in our case. This likelihood of rupture was unknown, but, given the thinning and fibrosis of the aneurysm wall confirmed on histopathology, rupture could have been a risk for our patient.

In conclusion, we report a good outcome after surgical resection of a left auricular aneurysm in a dog. This diagnosis should be included in dogs presenting with a soft tissue opacity associated with the left cranial margin of the cardiac silhouette.

Conflicts of interest

The authors do not have any conflicts of interest to disclose.

Acknowledgments

The authors wish to thank Jack Tully for obtaining and compiling the video images during surgery.

Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jvc.2018.12.004.

References

[1] Rishniw M, Erb H. Evaluation of four 2-dimensional echocardiographic methods of assessing left atrial size in dogs. J Vet Intern Med 2000;14:429—35.
[2] Hanson K, Haggstrom J, Kvart C, Lord P. Left atrial to aortic root indices using two-dimensional M-mode echocardiography in cavalier king charles spaniels with and without left atrial enlargement. Vet Radiol Ultrasound 2002;6:568—75.
[3] Cornell C, Kittleson M, Della Torre P, Haggstrom J, Lombard CW, Pedersen HD, Vollmar A, Wey A. Allometric scaling of M-mode cardiac measurements in normal adult dogs. J Vet Intern Med 2004;18:311—21.
[4] Johnson L, Boon J, Orton CE. Clinical characteristics of 53 dogs with Doppler-derived evidence of pulmonary hypertension: 1992-1996. J Vet Intern Med 1999;13:440—7.
[5] Krueger SK, Ferlic RM, Mooring PK. Left atrial appendage aneurysm: correlation of noninvasive with clinical and surgical findings: report of a case. Circulation 1975;52:732—8.
[6] Biasato I, Biasibetti E, Gili S, Bruatto G, Tarducci A, Guarda F, Capucchio MT. Right atrial appendage aneurysms in veal calves and beef cattle: anatomopathological investigations and aetiopathogenetic hypotheses. J Vet Cardiol 2017;19:68—73.
[7] Baron Toaldo M, Diana A, Morini M, Cipone M. Imaging diagnosis–intrapericardial right auricle aneurysm in a dog. Vet Radiol Ultrasound 2010;51:512—5.
[8] Schwarz T, Willis R, Summerfield NJ, Doust R. Aneurysmal dilatation of the right auricle in two dogs. J Am Vet Med Assoc 2005;226:1512—5.
[9] Misbach C, Pey P, Gouni V, Trehiou-Sechi E, Petit AM, Pouchelon J, Chetboul V. Antemortem diagnosis of a left auricular appendage herniation through a partial pericardial defect in a dog with degenerative mitral valve disease. Schweiz Arch Tierheilkd 2016;158:351—6.
[10] Chapel E, Russel D, Schober K. Partial pericardial defect with left auricular herniation in a dog with syncope. J Vet Cardiol 2014;16:133—9.
[11] Bramlet DA, Edwards JE. Congenital aneurysm of left atrial appendage. Br Heart J 1981;45:97—100.
[12] Gold JP, Afifi HY, Ko W, Horner N, Hahn R. Congenital giant aneurysms of the left atrial appendage: diagnosis and management. J Card Surg 1996;11:147—50.
[13] Kiaii B, Doll N, Kuehl M, Mohr FW. Minimal invasive endoscopic resection of a giant left atrial appendage aneurysm. Ann Thorac Surg 2004;77:1437—8.
[14] Terada H, Tanaka Y, Kashima K, Sannou K, Arima T. Left atrial diverticulum associated with severe mitral regurgitation. Jpn Circ J 2000;64:474—6.
[15] Acartürk E, Kanadaşi M, Yerdelen VD, Akpinar O, Ozeren A, Saygili OB. Left atrial appendage aneurysm presenting with recurrent embolic strokes. Int J Cardiovasc Imag 2003;19:495—7.
[16] Vagefi PA, Choudhry M, Hilgenberg AD. Excision of an aneurysm of the left atrial appendage. J Thorac Cardiovasc Surg 2007;133:822—3.
[17] DiBardino DJ, Aggarwal A, Knudson JD. Off-pump snare technique for congenital left atrial appendage aneurysm. Cardiol Young 2014;24:555—8.
[18] Kimura T, Takatsuki S, Miyoshi S, Katsumata Y, Nishiyama T, Nishiyama N, Tanimoto Y, Aizawa Y, Jinzaki M, Fukuda K. Pericardial endoscopy-guided left atrial appendage ligation: a pilot study in a canine model. Circ Cardiovasc Interv 2014;7:844—50.
[19] Hondo T, Okamoto M, Yamane T, Kawagoe T, Karakawa S, Yamagata T, Matsuura H, Kajiyama G. The role of the left atrial appendage. A volume loading study in open-chest dogs. Jpn Heart J 1995;36:225—34.
[20] Kamohara K, Popović ZB, Daimon M, Martin M, Ootaki Y, Akiyama M, Zahr F, Cingoz F, Ootaki C, Kopcak Jr MW, Dessoffy R, Liu J, Thomas JD, Gillinov AM, Fukamachi K. Impact of left atrial appendage exclusion on left atrial function. J Thorac Cardiovasc Surg 2007;133:174—81.