Open Veterinary Journal, (2024), Vol. 14(6): 1497-1502
ISSN: 2226-4485 (Print)
ISSN: 2218-6050 (Online)

Case Report
DOI: *10.5455/OVJ.2024.v14.i6.19*

Submitted: 05/03/2024 Accepted: 04/05/2024 Published: 30/06/2024

Prolonged survival with mitral valve plasty for acute mitral regurgitation due to mitral valve dysplasia and chordal rupture in a young small dog: A case report

Isamu Kanemoto[1,2*], Kippei Mihara[1], Kawase Koudai[1,3], Takanori Ando[1,4], Kazuhito Iguchi[1,5], Yuya Suzuki[1], Daisuke Taguchi[1,6] and Taiji Yamamoto[7]

[1]*Cardiac Surgery Team, Chayagasaka Animal Hospital, Nagoya, Japan*
[2]*Division of Experimental Animals, Nagoya University, Nagoya, Japan*
[3]*Sapporo Night Veterinary Hospital Emergency and Critical Care, Sapporo, Japan*
[4]*Heart-Will Animal Hospital, Kita-Kyushu, Japan*
[5]*Momijiyama Douri Hospital Pet Clinic, Nakano-ku, Tokyo, Japan*
[6]*Green Animal Hospital, Aomori, Japan*
[7]*Ugui Animal Hospital, Wakayama, Japan*

Abstract

Background: We aimed to report the second case of mitral valve plasty (MVP) for acute mitral regurgitation (MR) due to mitral valve dysplasia in a young small dog.

Case Description: A 5-month-old female Jack Russell, weighing 3.5 kg, presented with dyspnea and collapse upon excitation. Acute MR with pulmonary edema due to chordal rupture was diagnosed with a suspected congenital mitral valve anomaly. Despite treatment with high-dose drugs, heart failure symptoms and enlargement worsened. An artificial chordal replacement (ACR) was inserted using polytetrafluoroethylene sutures, and annuloplasty was performed. The dog was discharged on postoperative day 7. After 7 years, the dog underwent operations for complete anterior cruciate ligament tears with no cardiac signs. After 11.5 years, the dog showed no cardiac issues and died from a non-cardiac disease.

Conclusion: The MVP method with ACR employed demonstrated better durability and promoted longer survival than that of previous dog mitral valve replacements.

Keywords: Acute mitral regurgitation, Chordal rupture, Mitral valve dysplasia, Mitral valve plasty, Young small dog.

Introduction

Most mitral regurgitation (MR) cases with myxomatous degeneration, an acquired heart disease, occur in older, small dogs. There are a few reports of MR with mitral valve dysplasia, a congenital heart disease, in young, medium-sized (Sudunagunta *et al*., 2021) and large dogs (Litu and Tilley, 1975). Recently, surgery has been performed in patients with severe MR and refractory pulmonary edema despite medical treatment (Kanemoto *et al*., 2010; Uechi *et al*., 2012). There are some reports of mitral valve replacement (MVR) using a mechanical valve in large (Eyster *et al*., 1976; Orton *et al*., 2005) and small dogs (Taguchi *et al*., 2014). However, almost all MR procedures have been performed using mitral valve plasty (MVP) because there are no artificial valves of adaptable size and no need for anticoagulant therapy throughout life in small-sized dogs (Kanemoto *et al*., 2021). In MR due to mitral valve dysplasia, there are three reports of MVR using novel bioprosthetic valves because of the short duration of anticoagulant therapy in medium-sized dogs (Behr *et al*., 2007; White *et al*., 1995, 1997). However, there is only one report of MVP for MR due to mitral valve dysplasia in dogs (Griffiths *et al*., 2004). This case report presented MVP performed for acute MR due to mitral valve dysplasia and chordal rupture in a young small dog.

Case Details

Patient details

The patient was a female Jack Russell, 5 months old, weighing 3.5 kg, who presented with dyspnea, collapse, and occasional nausea upon excitation for 5 days.

Initial examination findings

Inspection revealed rapid breathing. A heart rate of 180 bpm, a Levine grade 3/6 high-tone systolic murmur at the apex, and lung rales in both posterior pulmonary lobes were detected via auscultation. A +90° mean electrical axis and pulmonary P wave in leads II, III, and

***Corresponding Author:** Isamu Kanemoto. Chayagasaka Animal Hospital, Nagoya, Japan.
Email: *kanemoto@ta2.so-net.ne.jp*

aVF could be distinguished on an electrocardiograph. Thoracic radiography scans revealed moderate heart enlargement [vertebral heart scale (VHS): 10.7 v, cardiothoracic ratio (CTR): 62%] and pulmonary edema in both posterior pulmonary lobes (Fig. 1a). A ruptured chorda on the posterior side of the anterior valve leaflet was visible on B-mode echocardiography scans. Color Doppler echocardiography scans revealed a moderate mosaic flow directed from the left ventricle (LV) to the posterior wall of the left atrium (LA) during systole (Fig. 2a). Finally, M-mode echocardiography scans revealed a left ventricular end-diastolic diameter (LVEdD) of 24.9 mm, left ventricular end-systolic diameter (LVEsD) of 11.4 mm, and left ventricular fractional shortening (FS) 54%.

Based on the examination results, the dog was diagnosed with complications of acute moderate MR due to chordal rupture and suspected congenital mitral valve anomaly. Although the cardiac signs became stable for a short period with medical treatment using multiple high-dose drugs (enalapril, lasix, and digitalis), heart failure signs and heart enlargement gradually

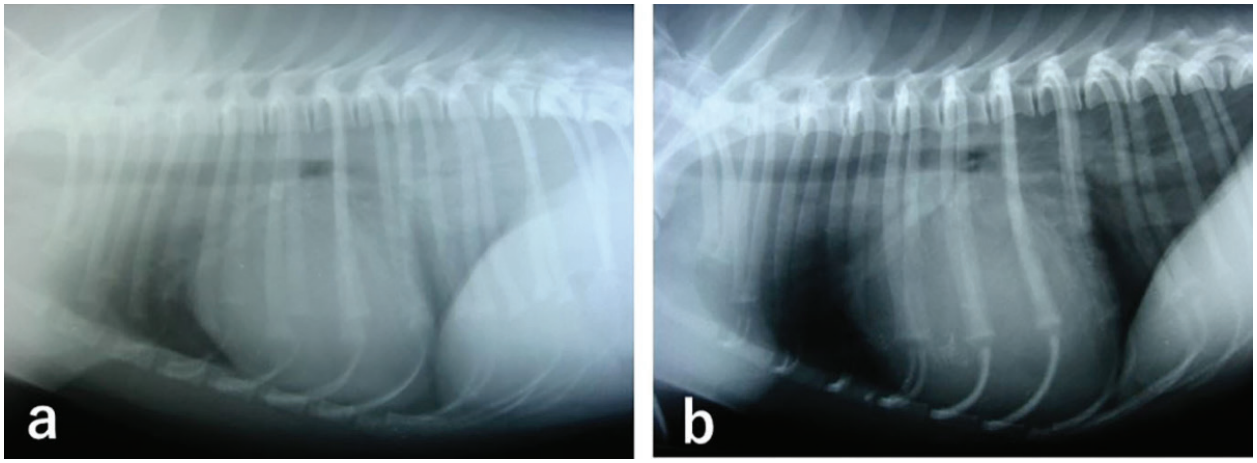

Fig. 1. Preoperative thoracic radiography (lateral view). (a) Thoracic radiograph recorded at the initial examination (5 months old) shows moderate heart enlargement (VHS, 10.7 v) and lung edema in the posterior pulmonary lobes. (b) Thoracic radiograph recorded after 4 months (just before surgery, 9 months old) shows heart enlargement (VHS, 11.2 v) with tracheal and left bronchial elevation and lung congestion. VHS: vertebral heart scale.

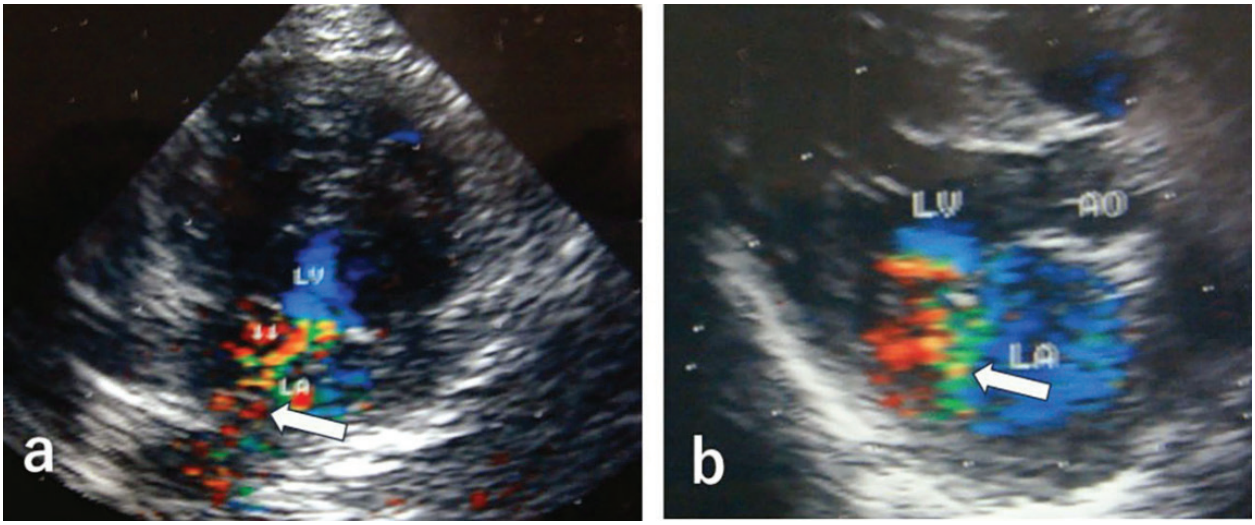

Fig. 2. Color Doppler echocardiography. (a) Color Doppler echocardiograph from the initial examination shows a mosaic flow (mitral regurgitation: large white arrow) during systole due to chordal rupture (small arrows) (two-chamber view). (b) Color Doppler echocardiograph recorded directly before surgery shows a mosaic flow (large white arrow) during systole retrograded along the posterior wall of the enlarged LA (four-chamber view). AO: aorta; LA: left atrium; LV: left ventricle.

worsened. When the dog was 9 months old, thoracic radiography scans showed VHS 11.2 v and CTR 70% and the elevation of the trachea (Fig. 1b). A moderate mosaic flow directed from the LV to the posterior wall of the LA during systole was visible on color Doppler echocardiography scans (Fig. 2b). Furthermore, M-mode echocardiography scans revealed an LVEdD of 36.9 mm, LVEsD of 11.9 mm, and FS of 46%. According to the owner's wishes, surgical treatment of the MVP was performed at age 9.5 months (weight, 4.2 kg).

Surgical methods

We used surface-cooling hypothermia, performed under isoflurane anesthesia combined with low-flow cardiopulmonary bypass (CPB) (Kanemoto *et al*., 2010, 2021). After induction of anesthesia, the dog was prepared for the surgical field in the right recumbent position. Venous (10 Fr) and arterial (8 Fr) cannulae were inserted into the left jugular vein and carotid artery, respectively, and both were connected to a CPB circuit (NAPS-S circuit and OLF oxygenator EC-30; Senco-Ika Company, Tokyo, Japan). After the fifth left thoracotomy, the LA was opened transversely, and the mitral valve was checked macroscopically. The anterior valve leaflet was largely ridden up due to chordal elongation and rupture (Fig. 3a). The lesion sites on the mitral valve are shown on the mitral valve map: the anterior commissure side (A1), middle portion (A2), and posterior commissure side (A3) in the anterior leaflet (Fig. 3b). Two ruptured chordae of the A2-3 and A3 portions in the anterior leaflet were reconstructed using two polytetrafluoroethylene (PTFE) sutures, connecting them to the posterior papillary muscle. Another elongated chorda of the A1-2 portion of the anterior leaflet was reconstructed using a PTFE suture between the A1-2 portion and the anterior papillary muscle. In addition, the Kay method (Kay and Egerton, 1963), with mattress sutures attached to two pledgets, was adapted to the posterior commissure for annuloplasty (AP) (Fig. 3c). Consequently, the mitral valve ring diameter decreased from 19 mm preoperatively to 17 mm postoperatively. The LA was routinely closed after the regurgitation flow test. Self-beating was immediately restored with no direct current

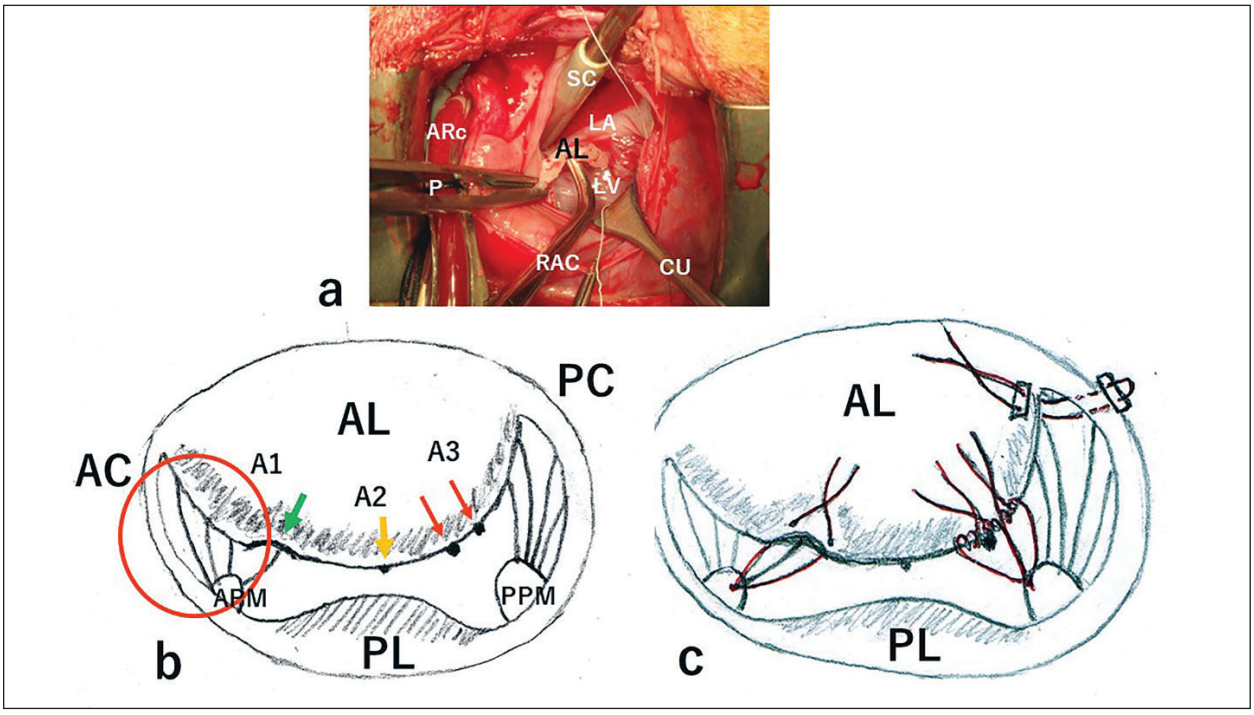

Fig. 3. Surgical view and pre- and postoperative schematics of MVP. (a) In the surgical view, the anterior valve leaflet (AL) is ridden up due to chordal rupture, shown by the right-angle clamp (RAC) and a pincette (P). To open up the surgical field, the posterior valve leaflet (PL) is pulled backward with a cross uncus (CU). (b) Pre-MVP schematic shows mitral valve dysplasia in the whole extent of the anterior commissure (AC) (in red circle), a bulge at A1-2 due to elongated chorda (green arrow), evidence of a chorda at A2 (orange arrow), and two chordal ruptures at A2-3 and A3 (red arrows). (c) The post-MVP schematic shows MVP with the artificial chordal reconstruction using three PTFE sutures between A1-2 of the AL and the anterior papillary muscle, between A2-3 of the AL and the posterior papillary muscle (PPM), and between A3 of the AL and PPM. In addition, annuloplasty was performed using the mattress technique (Kay method) with two pledgeted 5-0 Proline sutures in the posterior commissure. (A1): anterior commissure side of AL; (A2): middle portion of AL; (A3): posterior commissure side of AL; (ARc): aortic route cannula; LA: left atrium; LV: left ventricle; (SC): suction tube.

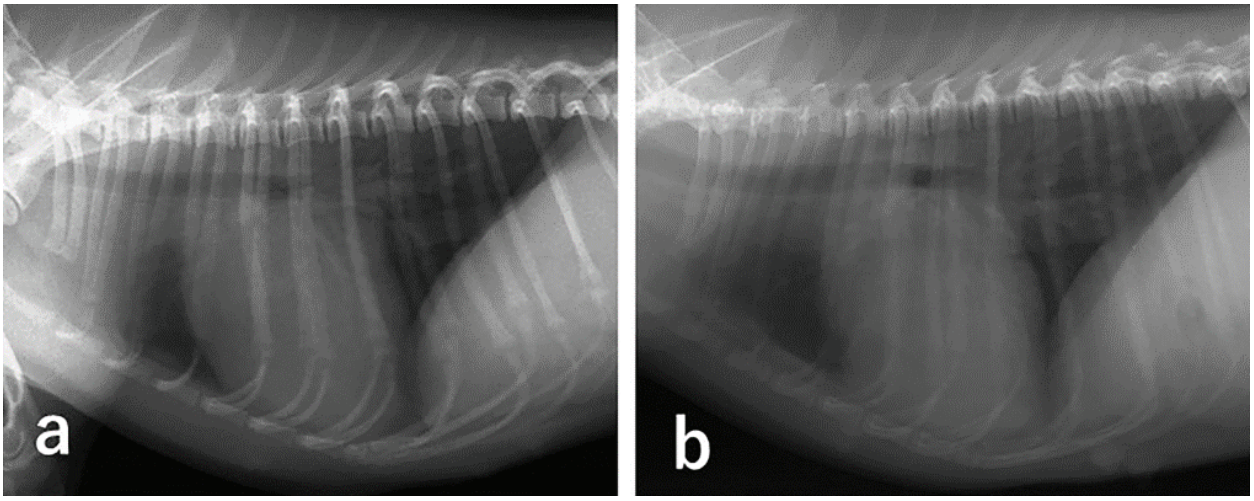

Fig. 4. Postoperative thoracic radiography (lateral). (a) Thoracic radiograph recorded 3 months postoperatively shows heart size reduction (VHS: from 11.8 v preoperatively to 10.5 v postoperatively). (b) At 7 years postoperatively, a thoracic radiograph shows heart size almost the same size (VHS: 10.9 v) as that at 3 months postoperatively. VHS: vertebral heart scale.

shock after removing air from the LV and releasing the aortic cross-clamp (ACC). The chest was routinely closed. In the present case, ACC time was 72 minutes, the lowest esophageal temperature was 20°C, the mean pump flow during ACC was 250 ml/minutes, and the pump time was 2 hours 25 minutes. The extubation time was 3 hours and 15 minutes postoperatively.

Postoperative course

The dog was discharged 7 days postoperatively with a good course. The dog was postoperatively administered only enalapril at the referral hospital because it was very active and had no cardiac signs. Postoperatively, auscultation revealed a persistent grade 2/6 systolic murmur. Thoracic radiography scans showed that VHS had decreased from 11.8 v preoperatively to 10.5 v at 3 months and 10.9 v at 7 years postoperatively (Fig. 4). Color Doppler echocardiography scans revealed a slight residual flow of MR in the anterior commissure. M-mode echocardiography showed a decreased LVEdD, from 36.9 mm preoperatively to 24.2 mm at 3 months and 23 mm at 7 years postoperatively, although it showed septal paradoxical motion postoperatively. At 7 years postoperatively, the dog underwent two consecutive operations for complete tears of the anterior cruciate ligament caused by furious active jumping. According to the referral hospital, the dog survived with no cardiac signs for 11 years and 6 months postoperatively until it died from a malignant tumor (hemangiosarcoma).

Discussion

In the present case, the middle portion (A2) and posterior side (A3) portion of the anterior valve leaflet appeared to be overloaded since birth due to mitral dysplasia on the anterior commissure side. In addition, the active dog presumably suddenly developed a chordal rupture (first at the A2 site) with acute MR. The dog's condition appeared to have worsened due to neighboring chordal ruptures (continued at A2-3 and A3).

Surgery for MR

There are two methods of MR: MVR using an artificial (mechanical or bioprosthetic) valve and MVP repairing a self-damaged valve. The advantage of MVR is the good durability of the valve, whereas the disadvantages are the need for lifetime anticoagulant therapy and the size limit of the valve in small dogs. Although MVP does not require anticoagulant therapy, the durability of the repaired valve can be rather low, prompting concern regarding its life expectancy. In our experience (Taguchi *et al*., 2014), a small dog that underwent MVR using a mechanical valve (smallest size: 19 mm) survived for 2 years and 1 month postoperatively. During that time, thrombosis-related events often occurred despite long-term anticoagulant (warfarin) therapy until death due to thromboembolism. In the present case, MVR was excluded because of the size limit of the artificial valve and the difficulty in administering anticoagulant therapy to small dogs. According to the long-term results of bioprosthetic MVR using the Carpentier-Eduward pericardial mitral valve in humans, structural valve failure occurred in 69%–85% at 10 years, especially in young patients due to calcification (Doenst *et al*., 2004). To date, there have been three reports of MVR due to mitral valve dysplasia in dogs (Behr *et al*., 2007; White *et al*., 1995, 1997). These reports focused on young dogs that underwent MVR using a bovine pericardial bioprosthetic valve. Although MVR using bioprosthetic valves requires the use of anticoagulant

drugs for a short duration, there is concern about the durability of the valve due to problems associated with aging. According to such reports, the valves had a maximum life expectancy of 17, 6, and 12 months postoperatively. According to Griffiths *et al.* (2004), two out of four dogs with mitral valve dysplasia and seven out of eight dogs with degenerated mitral valve disease had resolution of congenital heart failure with a median follow-up period of 1 year (range, 4 months to 3 years) at the time of the report. However, at 6 months postoperatively, one dog with mitral valve dysplasia died of progressive heart failure. In our case, MVP was performed 11 years and 6 months postoperatively, with no cardiac signs, until the patient died of a malignant tumor (hemangiosarcoma). Therefore, this report demonstrates the long-term durability of MVP and the possibility of long-term survival.

MVP method

There are three main methods of MVP: (1) AP for a dilated mitral annulus, (2) valvuloplasty for a deformed valve leaflet, and (3) chordal repair for ruptured or elongated chordae (Carpentier, 1983). Recently, a novel artificial chordal replacement (ACR) technique using a PTFE suture for ruptured or elongated chordae was developed in sheep (Vetter *et al*., 1986), humans (David *et al*., 1991), and dogs (Kanemoto *et al*., 2017a,b). MVP is usually a combination of two or three of the methods according to the mitral valve lesions. In the present case, the MVP consisted of a novel ACR using a PTFE suture for ruptured chordae in the anterior leaflet and the Kay method on the posterior commissure for the AP in a small dog. There are two reports that focused on long-term survival in small dogs (Mizuno *et al*., 2013; Kanemoto *et al*., 2017a,b). The patients in the report by Kanemoto *et al.* survived for 9 years and 1 month and 7 years and 10 months after surgery, respectively; both patients died of old age. Whereas in the report by Mizuno *et al*., the dogs survived for 5 years due to the recurrence of chordal rupture and for 6 years postoperatively at present. In our case, the dog survived without cardiac signs for 11 years and 6 months postoperatively and died from a malignant tumor unrelated to their heart condition. However, the Kay method may be more suitable when performing an AP with a mattress suture at the anterior commissural in mitral dysplasia because of the small residual regurgitation postoperatively.

Conclusion

To the best of our knowledge, this is the second report of MVP for acute severe MR due to chordal rupture and mitral valve dysplasia in a young small dog. The dog survived for 11 years and 6 months, which is longer than that in previous reports focusing on MVP in dogs. Therefore, MVP using the novel ACR with a PTFE suture may demonstrate better durability than that of previous MVR methods used in dogs.

Acknowledgments

The study was conducted at Nagoya, Japan's 16th Chubu Small Animal Research Annual Meeting (2007). We thank Editage (www.editage.jp) for the English language editing.

Conflict of interest

The authors declare that there is no conflict of interest.

Authors' contributions

IK and KM performed the examinations and surgical operations. IK wrote the manuscript. KK, TA, and KI assisted with the open-heart surgery. YS and DT assisted data collection. TY was the primary care doctor who referred the dog to our hospital.

Funding

This research received no specific grant.

Data availability

The data supporting the findings of this study are available from the authors upon request.

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