https://doi.org/10.17221/154/2019-VETMED

# Balloon valvuloplasty in two dogs with aortic valve stenosis showing congestive heart failure

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**Citation:** Yoshida T, Matsuura K, Goya S, Ma D, Shimada K, Kitpipatkun P, Takeuchi A, Uemura A, Tanaka R (2020): Balloon valvuloplasty in two dogs with aortic valve stenosis showing congestive heart failure. Vet Med-Czech 65, 89–94.

**Abstract:** A 10-year-old female Papillon and a 1-year-old male Golden Retriever were presented to the Tokyo University of Agriculture and Technology for a second opinion on an aortic valve stenosis (AS). The aortic flow rate was not as high as it should have been (the aortic flow velocity for case 1 and case 2 was 2.82 m/s and 3.96 m/s, respectively). However, the AS was suspected to be an exacerbating factor in the congestive heart failure, so that a balloon valvuloplasty was conducted. As a result, the congestion and clinical symptoms were much improved in both cases. In conclusion, in cases with an AS, in which afterload is a key factor for the exacerbation of the congestion, a balloon aortic valvuloplasty may reduce the afterload and consequently lead to an improvement in the congestion.

**Keywords:** interventional cardiology; congestive heart failure; dogs

Aortic valve stenosis (AS) is a congenital cardiac malformation that is common in large dogs (Patterson 1968; Pyle et al. 1976; Tidholm 1997; Ontiveros et al. 2019). In previous studies, balloon valvuloplasty was performed when the pressure gradient was ≥ 80 mmHg (flow rate ≥ 4.5 m/s) (Meurs et al. 2005; Shen et al. 2017). However, in a severe AS, the left ventricular function decreases due to a myocardial ischemia from the chronic elevation of the left ventricular pressure (Griggs et al. 1973; Bache et al. 1981; Alyono et al. 1986). Moreover, some cases showed a lower aortic flow velocity than expected (Kitabatake et al. 1990; Minners et al. 2008; Pibarot and Dumesnil 2012).

This study reports that a balloon aortic valvuloplasty was performed for an AS accompanied by congestion. The aortic flow velocity was slightly high in both cases and did not match the criteria for balloon valvuloplasty. However, we found that the AS was an exacerbating factor in the congestion, and that balloon valvuloplasty should be performed. As a result, the congestion and clinical symptoms improved prominently in both cases.

## Case descriptions

### CASE 1

A 10-year-old neutered female Papillon was presented to our university for a second opinion with regards to exercise intolerance and a moist soft cough.

On physical examination, right lateral moist lung sounds (crackles), a grade IV/VI left basilar and apical systolic murmur with a regular rhythm,

https://doi.org/10.17221/154/2019-VETMED

and a heart rate (HR) of 115 beats per minute (bpm) were found upon thoracic auscultation. Thoracic radiography revealed an increased vertebral heart score (12.9 v) and a left atrium enlargement. An increased pulmonary opacity in the right caudal lung lobe was also observed (Figure 1C).

On the transthoracic echocardiography, mitral valve insufficiency and an AS (aortic flow velocity, 2.82 m/s) with the left atrium enlargement were noted. These findings may have resulted from degeneration in the mitral valve and the right coronary cusp of the aortic valve (Figure 1A). Moreover, the following parameters were obtained: a left atrial/aortic root ratio (LA/Ao) of 2.29 and a peak Doppler mitral annular velocity at the early diastole (Peak E) of 2.03 m/s.

From the above findings, we diagnosed this case as being an AS and having mitral valve insufficiency with severe congestion. The internal medical treatment (furosemide 1.5 mg/kg b.i.d.) did not improve the conditions of the dog. Then, we found that the AS was an exacerbating factor of the mitral valve insufficiency with congestive heart failure (CHF) and performed a balloon aortic valvuloplasty.

As premedication, butorphanol (Vetorfar; Meiji seika pharma, Tokyo, Japan, 0.2 mg/kg, *i.v.*), midazolam hydrochloride (Dormicum; Astellas Pharma Inc, Tokyo, Japan, 0.2 mg/kg, *i.v.*), glycopyrrolate (Glycopyrrolate injection; Yogeshwari medicals, Maharashtra, India, 0.011 mg/kg, *s.c.*), and meloxicam (Metacam 0.5%; Boehringer Ingelheim Vetmedica, Tokyo, Japan, 0.2 mg/kg, *s.c.*) were ad-

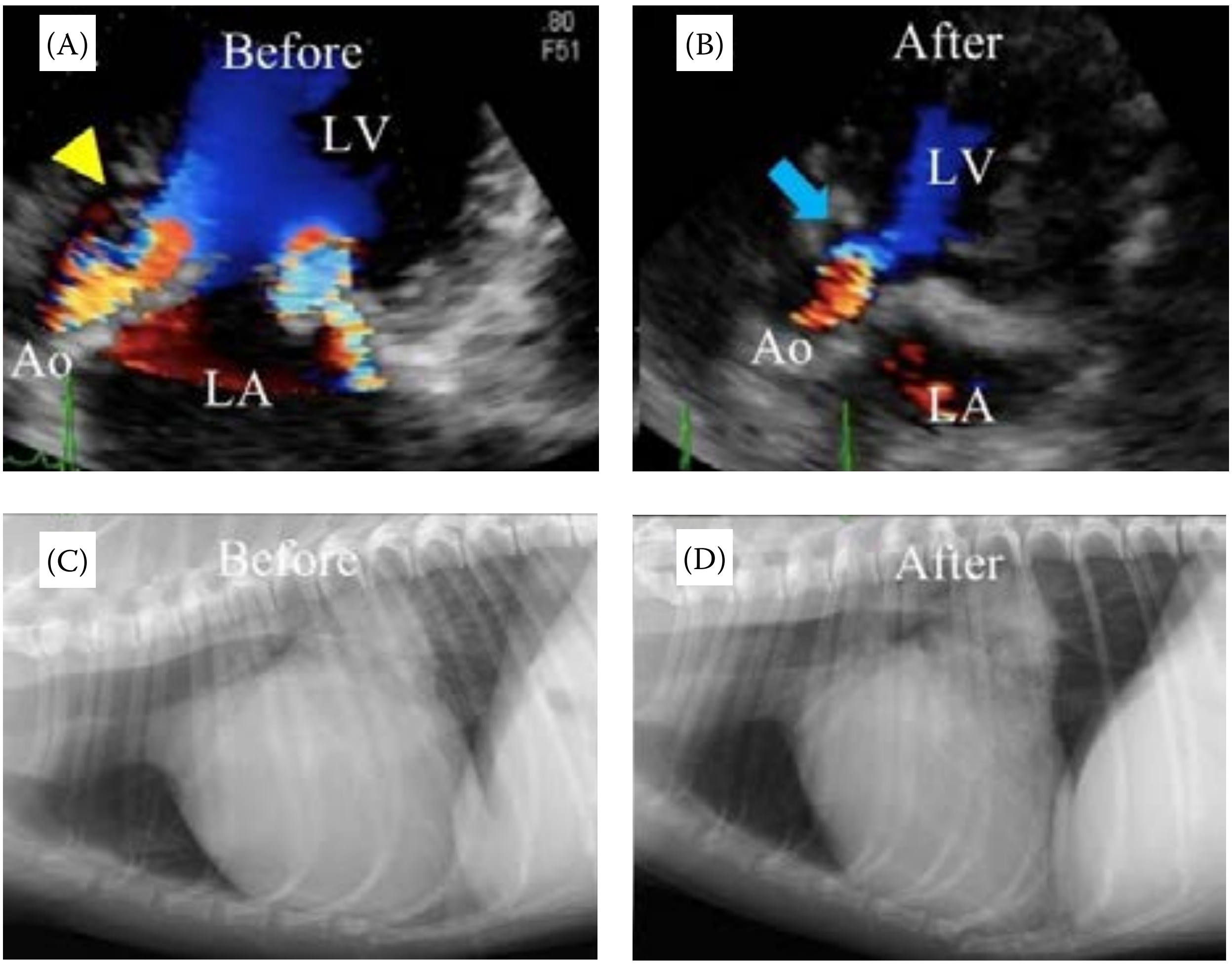


Figure 1. In case 1, the left parasternal apical five-chamber views of the colour Doppler imaging and the thoracic radiography before (A, C) and after the balloon valvuloplasty (B, D) are shown. The colour flow Doppler also demonstrates some turbulence at the level of the vascular stenotic lesion (A; yellow arrowhead). However, the turbulence reduced after the balloon valvuloplasty (B; blue arrow). On the thoracic radiography, the increased pulmonary opacity was resolved after the balloon valvuloplasty (C, D)

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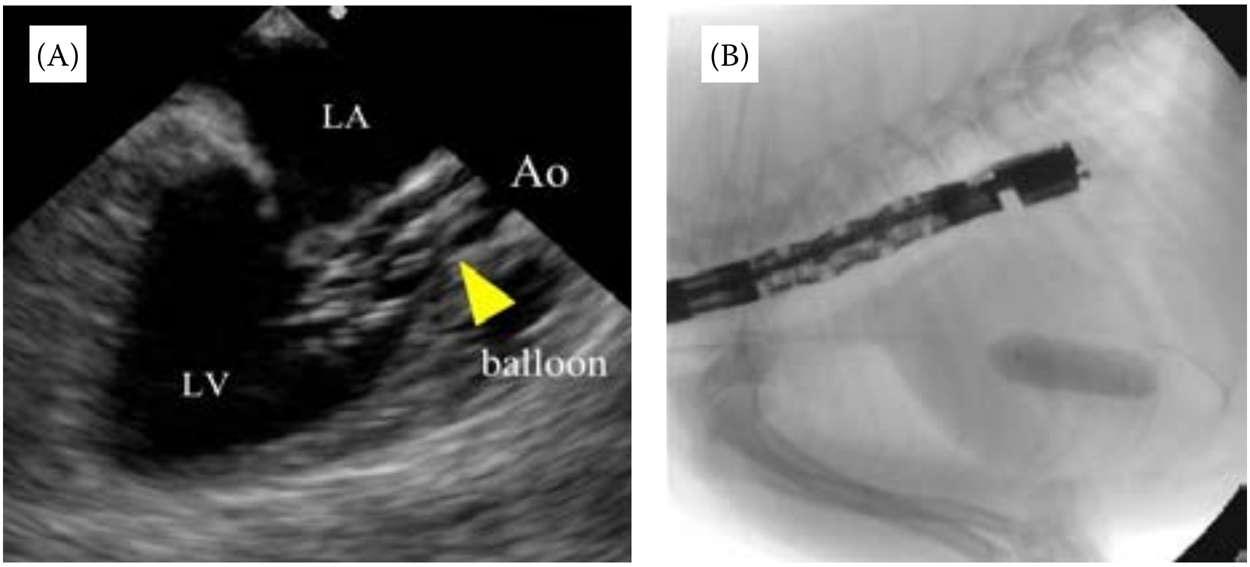


Figure 2. The TEE and fluoroscopic imaging in case 1 at the balloon valvuloplasty. (A) TEE imaging: The transverse middle-oesophageal long-axis-view was obtained with the array angle set to 130°. The balloon was inflated and deflated four times (arrowhead). (B) The fluoroscopic imaging at the balloon valvuloplasty

ministered. Additionally, heparin sodium (Heparin sodium; Eapharma, Tokyo, Japan, 100 IU/kg, *i.v.*) was administered for thrombosis prevention. Anaesthesia was induced with propofol 1% (Propofol Mylan; Mylan Seiyaku, Tokyo, Japan, 6 mg/kg bolus, *i.v.*) and maintained with 1–2 vol% of isoflurane (Isoflurane for Animal Use; Intervet, Osaka, Japan) in 100% oxygen.

The catheterisation was performed under fluoroscopic and transoesophageal echocardiographic (TEE) guidance. An 18-G peripheral venous catheter was inserted into the left carotid artery, and a 4-Fr vascular introducer sheath was placed inside. After placing the sheath, a 0.014” × 175 cm guidewire was inserted from the sheath and advanced across the aortic valve. The stenosis was confirmed by TEE and fluoroscopy. A 10 × 40-mm TMP PED balloon catheter (Tokai Medical Products paediatrics balloon catheter; Tokai Medical Products, Kasugai, Aichi, Japan) was selected for the balloon valvuloplasty and advanced over the guidewire to the level of stenosis. The balloon was inflated and deflated four times consecutively with a two minute break between inflations (Figure 2A and 2B). After the TEE confirmation of the improvement in the AS, the balloon valvuloplasty was discontinued.

The following postoperative day, an echocardiography was performed (Figure 1B). The aortic flow velocity decreased from 2.82 m/s to 1.31 m/s (HR, 105 bpm). The Peak E also decreased (from 2.03 m/s to 1.45 m/s). On the thoracic radiography, an increased pulmonary opacity, localised in the right caudal lung lobe, was resolved (Figure 1D). A re-examination was performed after 1 year. On the echocardiography, neither a restenosis nor the deterioration of the congestion were noted (aortic flow velocity of 1.09 m/s, Peak E of 1.32 m/s, Peak E/Ea Sep of 25.1, Peak E/Ea Lat of 20.65) (Table 1).The owner reported the dog was clinically normal with no sign of weakness, collapse, or reduced exercise tolerance.

Table 1. Changes in the echocardiographic findings and the X-ray findings before and after the balloon aortic valvuloplasty

| | Case 1 | | | Case 2 | | |
|---|---|---|---|---|---|---|
| | Ao flow (m/s) | Peak E (m/s) | Pulmonary oedema (+/–) | Ao flow (m/s) | Peak E (m/s) | Pulmonary oedema (+/–) |
| Before operation | 2.82 | 2.03 | + | 3.96 | 2.93 | + |
| After operation | 1.31 | 1.45 | – | 2.33 | 1.48 | – |
| After one year | 1.09 | 1.32 | – | 2.25 | 1.7 | – |

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## CASE 2

A 1-year-old male Golden Retriever was presented to our university for a second opinion regarding a cough and exercise intolerance. On physical examination, a grade IV/VI left basilar systolic murmur with a regular rhythm and a HR of 112 bpm were noted upon auscultation. The thoracic radiography revealed an increased vertebral heart score (12.3 v) and an increased pulmonary opacity that was localised in the right and left caudal lung lobes (Figure 3C).

The transthoracic echocardiography showed a severe subvalvular AS (SAS) characterised by a membrane-like structure just below the aortic valve (flow velocity of 3.96 m/s) (Figure 3A). The left atrium was enlarged, and mitral regurgitation was also observed (LA/Ao of 3.0). Moreover, the following parameters were obtained: the left ventricular measurements included an end-diastolic dimension (LVIDd) of 73.1 mm, a fractional shortening (FS) of 23.4%, and a Peak E of 2.93 m/s. From the above findings, we diagnosed this case as SAS. Additionally, SAS was considered an exacerbating factor for the congestion. We considered the use of a diuretic to improve the CHF. However, because the blood pressure was low (systolic blood pressure of 90 mmHg), in this case, and the diuretic agents could worsen hypotension, a balloon valvuloplasty was performed.

The balloon valvuloplasty was performed under the TEE guidance. The anaesthesia protocols and

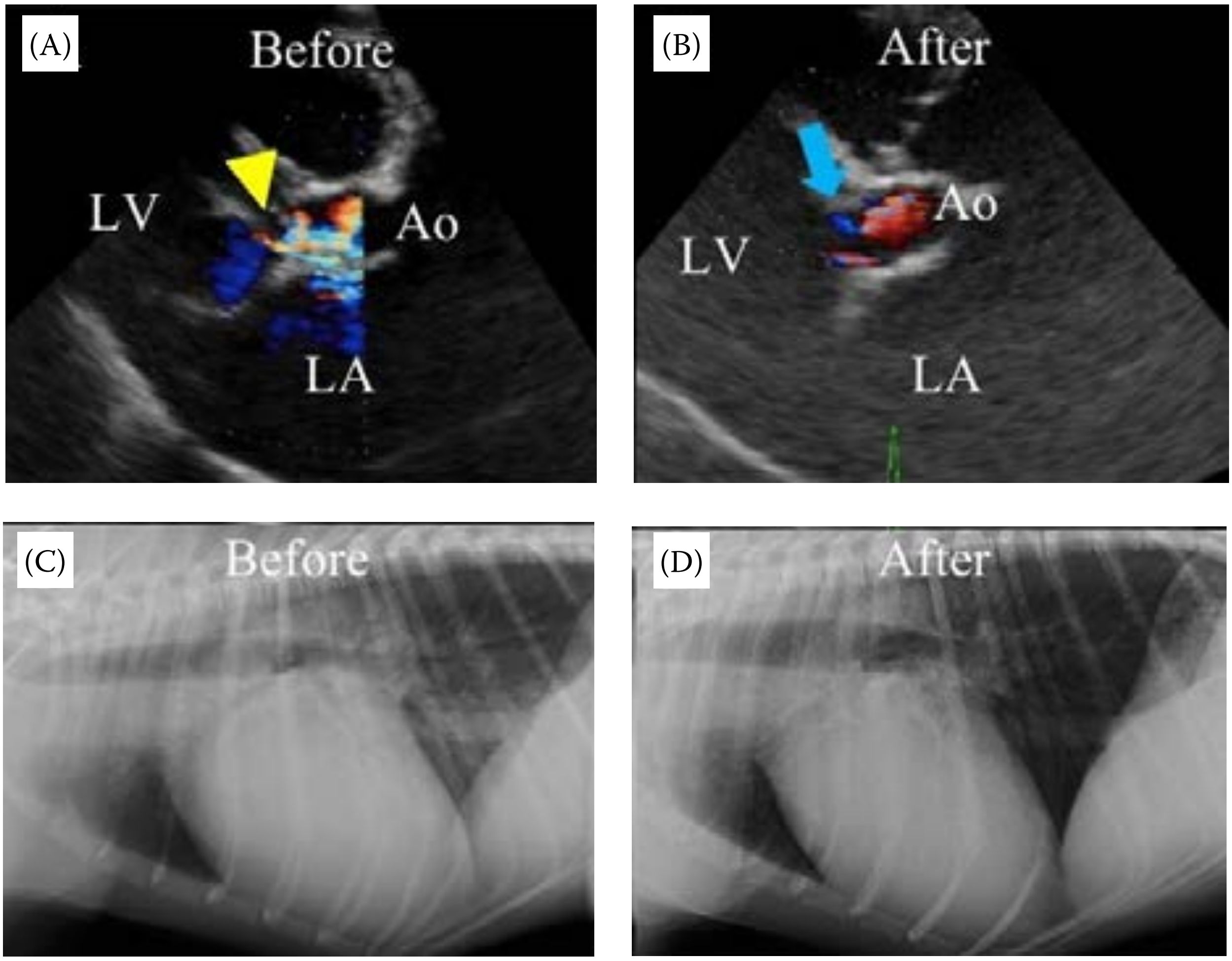


Figure 3. In case 2, the right parasternal long-axis LV outflow views of the colour Doppler imaging and the thoracic radiography before (A, C) and after the balloon valvuloplasty (B, D) are shown. The colour flow Doppler shows turbulence originating across the fibrous membrane of the subvalvular aortic ridge (A; yellow arrowhead). After the balloon valvuloplasty, the turbulence reduced (B; blue arrow). Moreover, the increased pulmonary opacity was resolved on the thoracic radiography after the balloon valvuloplasty (C, D)

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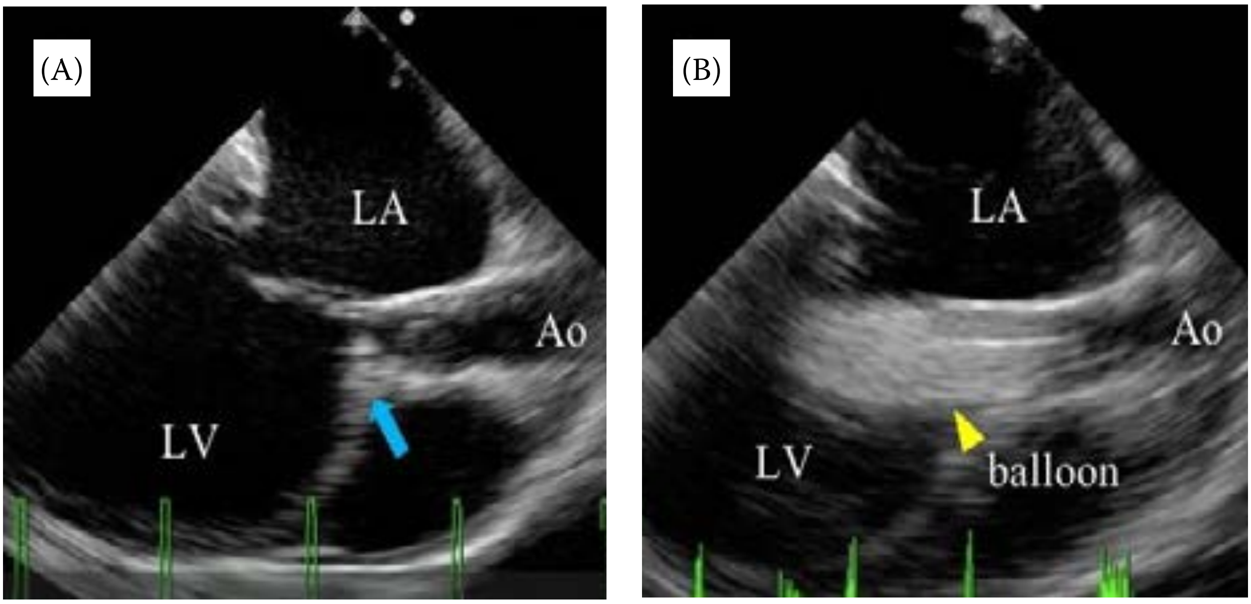


Figure 4. The TEE imaging, the transverse middle-oesophageal long-axis-view was obtained with the array angle set to 105° in case 2. (A) The TEE imaging before the balloon valvuloplasty, the blue arrow shows the stenosis site. (B) The TEE imaging at the balloon valvuloplasty. The yellow arrowhead shows the balloon

procedures before the sheath insertion were performed as described in case 1.

An 8-Fr vascular introducer sheath was placed inside. After placing the sheath, a 0.035” × 260-cm guidewire was inserted from the sheath and advanced across the aortic valve. The guidewire insertion was slightly difficult due to the presence of a pinhole-shaped membrane-like structure below the aortic valve. A multipurpose catheter was inserted to measure the pressure and determine the location of the stenosis by angiography. Subsequently, a 15 × 40-mm balloon catheter (Tyshak I; NuMED Canada, Cornwall, ON, Canada) was advanced along the guidewire to the level of the stenosis and dilated several times. The dilation procedure was then repeated using an 18 × 40-mm balloon catheter. The balloon was dilated four times with a break of a few minutes between dilations. Upon the TEE observation, the SAS improved compared with that before the dilation (Figures 4A and 4B). After dilation, the balloon and guidewire were removed.

The following postoperative day, a transthoracic echocardiography was performed (Figure 3B). The aortic flow decreased from 3.96 m/s to 2.33 m/s (HR, 90 bpm). The Peak E also decreased from 2.93 m/s to 1.48 m/s. On the thoracic radiography, an increased pulmonary opacity, which was localised in the right and left caudal lung lobes, was resolved (Figure 3D).

After one year, we performed the re-examination. On the echocardiography, the aortic flow velocity was slightly higher (aortic flow velocity of 2.25 m/s) and the congestion was slightly worse (Peak E of 1.7 m/s) (Table 1). However, the owner reported the dog was clinically normal with no history of weakness, collapse, or reduced exercise tolerance.

## DISCUSSION AND CONCLUSIONS

In this study, balloon valvuloplasty was performed for AS with severe congestion. Based on previous studies (Alyono et al. 1986; Meurs et al. 2005), these cases did not match the criteria for balloon dilation. However, balloon valvuloplasty was quite effective in reducing the congestion in these cases. In case 1, the mitral valve insufficiency increased the left atrial pressure, leading to severe congestion. Moreover, the AS also resulted in the increased left ventricular pressure and exacerbated the congestion. At this point, the balloon valvuloplasty was effective in resolving the exacerbation of the congestion by reducing the left ventricular pressure. In case 2, a significant afterload from the AS caused CHF and left ventricular dysfunction. Because the blood pressure was low due to the left ventricular dysfunction and diuretic agents could worsen the hypotension, we could not use diuretic agents. Therefore, we per-

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formed a balloon aortic valvuloplasty to improve the afterload and reduce the congestion. As a result, an improvement in the symptoms and echo parameters was observed.

In previous studies, no clear improvement in survival time was observed in dogs that underwent balloon valvuloplasty compared with those treated with atenolol (Alyono et al. 1986; Eason et al. 2014). In our cases, the valvuloplasty was effective in improving the clinical symptoms and the congestion although the long-term prognosis is uncertain. However, this procedure is effective in reducing the mortality rate due to the congestion and may improve the prognosis.

Therefore, in the case of AS, in which an afterload is a key factor for the exacerbation of the congestion, balloon aortic valvuloplasty may reduce the afterload and consequently improve the congestion.

## Conflict of interest

The authors declare no conflict of interest.

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Received: November 2, 2019
Accepted: January 5, 2020