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Case Report

# Partial anomalous pulmonary venous connection in a dog☆

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**Abstract** A 2-year-old male intact Belgian Malinois was presented for exercise intolerance. A grade III/VI left basilar systolic murmur was detected. Echocardiography revealed moderate right atrial and ventricular dilation and increased pulmonic outflow velocity. Thoracic radiographs showed right heart enlargement and a dilated caudal vena cava. In addition, on the left lateral projection, an enlarged aberrant right cranial pulmonary lobar vein was suspected to be diverging ventrally from the course of the right cranial lobar bronchus and inserting more ventrally than normal in the region of the right atrium. A left-to-right pulmonary vascular shunt was suspected, and the patient underwent further diagnostics under general anesthesia. An agitated saline study was positive, suggestive of a concurrent right to left shunt. A right heart catheterization was performed. Angiography was inconclusive. Oximetry testing revealed an increase in oxygen saturation within the right atrium at the level of the caudal cava supportive of a left-to-right shunt in this region. Computed tomography angiography revealed a large single pulmonary vein that anomalously entered into the caudolateral aspect of the right atrium (left-to-right shunt) and was suspicious for a small arteriovenous malformation between

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the right caudal pulmonary artery and the right pulmonary vein returning to the left atrium (right to left shunt). The patient was diagnosed with a partial anomalous pulmonary venous connection and a possible arteriovenous malformation.
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**Abbreviations**

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| ARPV | anomalous right pulmonary vein |
| ASD | atrial septal defect |
| CTA | computed tomography angiography |
| PAPVC | partial anomalous pulmonary venous connection |

## Case description

A 2-year-old male intact Belgian Malinois presented to the cardiology service at the Matthew J. Ryan Veterinary Hospital of the University of Pennsylvania School of Veterinary Medicine for further evaluation of mild exercise intolerance and a cardiac murmur detected on routine physical examination. On cardiopulmonary examination, the dog had a grade III/VI ejection-quality left basilar systolic murmur, normal bronchovesicular lung sounds, and femoral pulses that were strong and synchronous. There was no overt jugular venous distension and the remainder of the physical examination was within normal limits.

Two-dimensional echocardiography showed moderate dilation of the right atrium and right ventricle. No atrial septal defect (ASD) was identified using color flow Doppler. The tricuspid valve leaflets appeared mildly thickened, and there was moderate tricuspid valve regurgitation. Tricuspid regurgitation velocity was mildly increased (2.89 m/s; reference 1.94—2.24 m/s), equating to a pressure gradient of 33.4 mmHg which suggested a right ventricular pressure over 40 mmHg assuming a right atrial pressure of 10 mmHg [1]. Pulmonic outflow velocity was increased (2.71 m/s; reference 1.05 $\pm$ 0.19), equating to a systolic pressure gradient of 29.7 mmHg and an estimated right ventricular pressure of 55 mmHg assuming a systolic PA pressure of 25 mmHg [1]. Tricuspid regurgitation velocity may have been underestimated due to less than perfect cursor alignment given the discrepancy in these estimated pressure gradients. The flow profile of pulmonic outflow appeared normal (Type I), and ejection time (220 ms; reference 194 ms $\pm$ 23) and acceleration time (100 ms; reference 79 ms $\pm$ 17) were both high-normal [1]. The pulmonic valve appeared normal with no insufficiency. Left atrial dimension, left atrial to aortic root ratio, and estimated left ventricular filling pressures were within reference ranges. The remainder of the echocardiographic examination was within normal limits. The patient was diagnosed with tricuspid valve regurgitation and right heart enlargement, which was suspected to be secondary to tricuspid valve dysplasia. As a step-up in velocity was not noted immediately before the pulmonic valve and the leaflets appeared normal, relative pulmonic stenosis was considered more likely. The cardiac murmur was suspected to be due to this relative stenosis. A recheck examination was recommended in one year unless the patient developed clinical signs of worsening disease.

The patient was represented to the cardiology service 5 months later for occasional episodes of disorientation during which the owner described palpable cold areas on the dog's face. Physical examination was unchanged. An electrocardiogram showed sinus rhythm with a right axis deviation but was otherwise within normal limits. Echocardiography was repeated and was relatively unchanged from previous examination except that the tricuspid regurgitation appeared subjectively less severe. With more critical evaluation of the tricuspid valve anatomy, it was believed that the tricuspid valve thickening and the degree of tricuspid regurgitation were not significant enough to explain the degree of right heart enlargement that was present. Based on the moderate right heart enlargement despite only mild tricuspid valve disease, a left-to-right shunt was suspected. The pulmonary-to-systemic flow ratio (Qp:Qs) was calculated using the velocity time integrals of pulmonic and aortic outflow pulse wave Doppler tracings and cross-sectional areas of the left and right ventricular outflow tracts as measured on echocardiography. The shunt ratio was estimated to be 3.5, supporting a large left-to-right shunt (reference $<$1.5 small, $>$2.0 large) [2]. However, Qp:Qs as calculated in this manner is limited when valvular regurgitation is present [3]. The moderate amount of tricuspid regurgitation could have significantly affected pulmonic velocity time integral and caused

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