Transvalvular Pulmonary Stent Angioplasty for Management of an Intraluminal, Compressive Chemodectoma in a Dog

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INTRODUCTION

Chemodectoma is a common cardiac neoplasia in dogs.[1-4] It may be diagnosed incidentally on echocardiography, and a common clinical consequence of this neoplasia is pericardial effusion with or without cardiac tamponade.[3,5,6] Rarely, compression of the pulmonary artery or its branches by this neoplasia has been described in dogs.[7,8] Here we present a case of a chemodectoma causing acquired pulmonary valvular obstruction in a dog, with subsequent treatment using transvalvular pulmonary stent angioplasty.

CASE PRESENTATION

A 10-year-old male neutered Boston terrier was presented to the oncology service of the Auburn University Veterinary Teaching Hospital for evaluation of a pleural and peritoneal effusion of 1 week's duration. Before this evaluation, no obvious clinical signs had been reported. Three years before presentation, the dog was tentatively diagnosed with a chemodectoma at the base of the heart. At that time, surgical biopsy of the mass and subtotal pericardiectomy were performed, which confirmed the diagnosis of chemodectoma. Thoracocentesis and abdominocentesis were performed at a veterinary clinic before the current presentation.

Two-dimensional and M-mode transthoracic echocardiography revealed mild mitral regurgitation and normal left atrial and left ventricular internal dimensions. The right atrium and right ventricle were severely dilated (Figure 1A).

Moderate concentric hypertrophy of the right ventricular walls was observed, and dilation of the coronary sinus was present. Moderate tricuspid regurgitation was observed, with elevated peak systolic velocities (5.18 m/sec), suggestive of a right ventricular–to–right atrial systolic pressure gradient of 107 mm Hg (Figure 1B). The previously diagnosed chemodectoma was observed in close association with the aortic root and main pulmonary artery (Figure 1C). This mass was hypoechoic, large, and lobulated (Video 1). Color flow Doppler imaging revealed flow acceleration within the right ventricular outflow tract (RVOT) just proximal to the mass and also severe external compression of the main pulmonary artery at the level of the pulmonary valve. Two tortuous, discrete jets of systolic blood flow were observed traversing the mass at the pulmonary valve (Figure 1D, Video 2). Turbulent blood flow was noted in the right and left pulmonary arteries, and a discrete level of stenosis was not observed distal to the mass in either branch. This was suggestive of one broad level of obstruction at the level of the pulmonary valve. External compression and intraluminal invasion of the main pulmonary artery were suspected. Continuous-wave, color Doppler interrogation of transpulmonic systolic flow revealed a peak velocity of 4.6 m/sec, suggestive of a right ventricular–to–pulmonary artery systolic pressure gradient of 85 mm Hg. The pulmonary valve could not be clearly imaged. The pulmonary annular diameter could not be measured, because of the size, invasion, and compression by the chemodectoma. The aortic annular diameter was measured (10 mm) and used as a surrogate to estimate the size of the pulmonary artery. Additional findings included dorsal compression of the left atrial wall by the mass and mild pleural effusion. Abdominal ultrasonography revealed an enlarged liver, dilated hepatic veins, a dilated caudal vena cava, and a mild amount of anechoic peritoneal fluid. On the basis of the severity of right heart changes secondary to the severe, acquired pulmonary obstruction, these findings were consistent with congestion and right-sided congestive heart failure.

Treatment options including chemotherapy, radiation therapy, and transvalvular pulmonary artery stent implantation were discussed. Transvalvular pulmonary artery stent angioplasty was chosen, and the dog was brought back 1 week later for the interventional procedure. General anesthesia was induced, and the dog was placed in left lateral recumbency. A surgical approach was made to isolate the left femoral artery. Through this artery, a 4-Fr nontapered angle catheter was positioned in the aortic root near the aortic valve for selective angiography. This angiogram revealed two coronary arteries originating from the aortic root, with a normal course and no obvious evidence of coronary arterial compression. Percutaneous access to the right jugular vein was then obtained, and a 6-Fr Berman angiographic catheter was positioned in the RVOT for selective angiography. This angiogram revealed a dilated RVOT and a large, trilobed mass compressing the distal RVOT and invading the main pulmonary artery at the level of the pulmonary valve (Figure 2A, Video 3).

A super-stiff guidewire was positioned in the distal left pulmonary artery, and a 6-Fr guiding sheath was moved into the RVOT for additional angiography and stent placement (Figure 2B, Video 4). A 10 mm × 3 cm self-expanding Nitinol vascular stent was then deployed at the level of the mass. Repeat angiography revealed subjectively improved blood flow past the mass via the stent (Figure 3A).

However, just beneath the deployed stent at the distal RVOT, there still appeared to be narrowing of the RVOT from the mass. For this reason, a 10 mm × 4 cm self-expanding Nitinol vascular stent was

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VIDEO HIGHLIGHTS

Video 1: Transthoracic echocardiography, right parasternal short-axis view, demonstrating the position of the previously diagnosed chemodectoma at the level of the pulmonary valve. The large size and lobulated character of the mass are evident.
Video 2: Transthoracic echocardiography, right parasternal short-axis view, demonstrating the abnormal movement of blood flow across the mass on color Doppler imaging. Note the turbulent, tortuous pathways that blood takes to cross the pulmonary valve, suggestive of blood flow through or around the intraluminal mass.
Video 3: Left lateral positioning and a selective RVOT injection using a balloon-tipped catheter. The trilobed chemodectoma is outlined by contrast as it moves past the mass distally into the pulmonary arteries. An open end-hole catheter is observed terminating in the ascending aorta, and there is a marker catheter in the esophagus. The dog's head is to the right in these images.
Video 4: Left lateral positioning and a selective RVOT injection using a guiding sheath over a super-stiff guidewire. The guidewire is positioned into the distal left pulmonary artery. The tip of the guiding sheath is positioned near the pulmonary valve. An open end-hole catheter is observed terminating in the ascending aorta, and there is a marker catheter in the esophagus. The dog's head is to the right in these images.
Video 5: Left lateral positioning and a selective RVOT injection using a guiding sheath over a super-stiff guidewire. The guidewire is positioned into the distal left pulmonary artery. Both stents have been deployed across the mass, and blood flow through the stents is observed. An open end-hole catheter is observed terminating in the ascending aorta, and there is a marker catheter in the esophagus. The dog's head is to the right in these images.
Video 6: Transthoracic echocardiography, right parasternal short-axis view, demonstrating the position of the vascular stent across the obstruction at the level of the pulmonary artery.
Video 7: Transthoracic echocardiography, right parasternal short-axis view, demonstrating blood flow through the vascular stent with color Doppler imaging. Stent patency and pulmonic regurgitation are observed.

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deployed within the first stent, such that the narrowing of the distal RVOT was relieved. Subsequent angiography revealed further subjective improvement of blood flow through the RVOT and pulmonary artery via the vascular stents (Figure 3B, Video 5). Equal blood flow to the right and left pulmonary arteries was observed, indicating that there was no obstruction caused by the deployment of the stents. Catheters were removed, and the dog recovered from anesthesia without complication.

The following day, transthoracic echocardiography and thoracic radiography were performed. Both modalities revealed stable position of the vascular stents (Figure 4, Video 6), and transthoracic echocardiography revealed a decrease in stenosis severity across the pulmonary artery.

Postoperative transpulmonic peak systolic velocity was documented at 2.6 m/sec, indicating a decrease in systolic, transpulmonic obstruction gradient of approximately 60 mm Hg (Figure 5, Video 7).

Intraluminal thrombi were not observed, and there was no pericardial effusion. The dog was discharged receiving clopidogrel to prevent thrombus formation. One week after discharge, the dog again developed abdominal effusion and was taken to a local emergency clinic. Because of persistence of effusion, the dog's owner elected euthanasia. Diagnostic tests and a necropsy were not performed.

DISCUSSION

Common cardiac tumors in dogs include hemangiosarcoma, aortic body tumors (which include chemodectomas and paragangliomas), and lymphoma.[1-5] Of these, chemodectomas are the second most commonly diagnosed.[1-5] In addition to chemodectomas, ectopic thyroid tumors are also found at the base of the heart.[1-5] Chemodectomas are tumors of paraganglial cells that are nonfunctional and are generally considered benign, with low metastatic potential.[3] As these neoplasias have an intrapericardial location, they may induce the production of pericardial effusion. Sometimes the tumor and pericardial effusion may be diagnosed incidentally, whereas other times the volume of pericardial effusion is great enough or the accumulation rate fast enough to induce signs of cardiac tamponade.[5,6] The dog in this report did not have pericardial effusion, but this is likely due to the previous subtotal pericardiectomy. Although it is unknown why this dog had persistent effusion resulting in euthanasia after stent implantation, it is possible that a complication related to the stent, the severity of right heart disease, or both contributed. Stent crimping after deployment,[7] stent fracture,[8] and stent migration[8] have all been reported as possible complications, and it is unknown if any of these occurred in this dog. Additionally, the severity of right heart failure may have been worsened if the mass partially compressed the right atrium or vena cava, which would not have been improved by stent implantation in the pulmonary artery.

This dog had acquired pulmonary stenosis secondary to compression and invasion of the main pulmonary artery by the chemodectoma. No evidence of right atrial compression was observed echocardiographically, but possible compression of the right atrium or vena cava by the mass could not be ruled out. Compression of structures near the base of the heart by a tumor has been described in dogs and in humans.[9-14] In a report describing acquired pulmonary stenosis in four dogs, one Boston terrier was described as having a heart-base mass compressing both the right and left pulmonary arteries and secondary right-sided congestive heart failure.[9] That dog also had compression of the left atrium secondary to the mass. Medical management for the right-sided heart failure was pursued in that case.[9] In a different veterinary report, right pulmonary artery compression by a heart-base mass was diagnosed in a French bulldog.[10] In that dog, compression of the right pulmonary artery was relieved with implantation of a balloon-expandable vascular stent.[10] Acquired pulmonary stenosis has also been reported in humans, with one report highlighting a supravalvar location of stenosis secondary to a pulmonary sarcoma.[11] In another report, severe stenosis of the left pulmonary artery secondary to squamous cell carcinoma was diagnosed in a 61-year-old man.[12] In that case, the stenosis was relieved with implantation of a self-expanding Nitinol vascular stent.[12] Mediastinal lymphoma and metastatic bronchial carcinoid have also

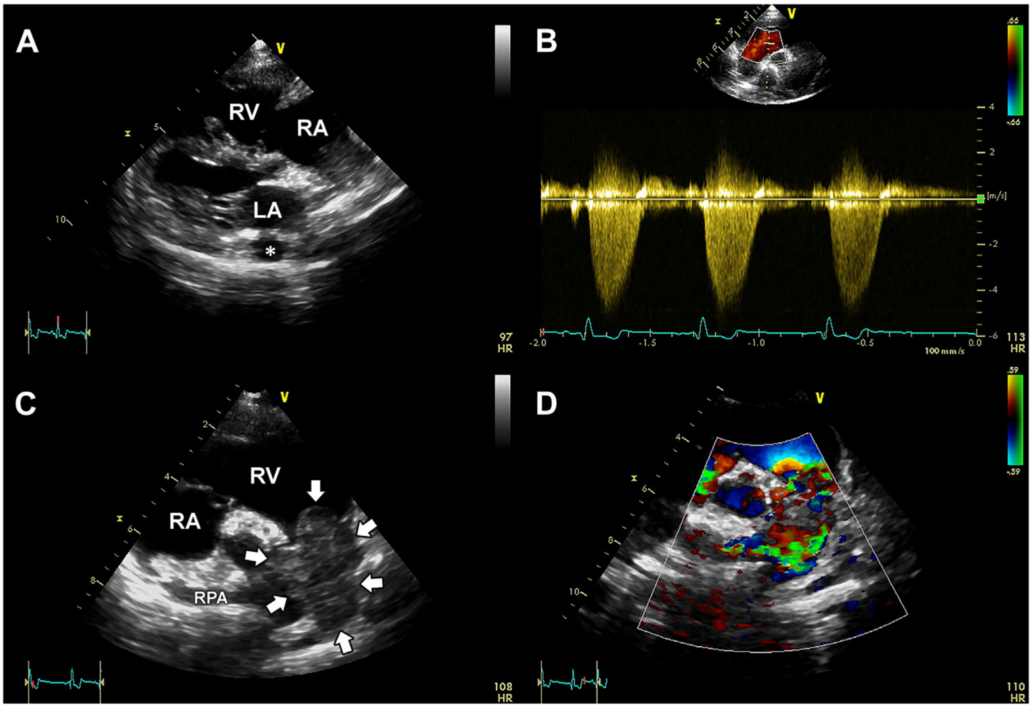

Figure 1 Preoperative two-dimensional transthoracic echocardiogram. **(A)** Right parasternal long-axis view demonstrates that the right ventricle (RV) has moderate concentric hypertrophy, and the right atrium (RA) and RV are severely dilated. The coronary sinus (*asterisk*) is also dilated. **(B)** Continuous-wave Doppler interrogation of tricuspid regurgitant velocities from the right parasternal short-axis view. **(C)** Right parasternal short-axis view demonstrates that the large mass is observed at the level of the pulmonary valve (*arrows* indicate border of mass). **(D)** Color flow Doppler imaging in the right parasternal short-axis view. Blood flow around and through the mass at the level of pulmonary valve is imaged, consistent with external compression and intraluminal invasion. *LA*, Left atrium; *RPA*, right pulmonary artery.

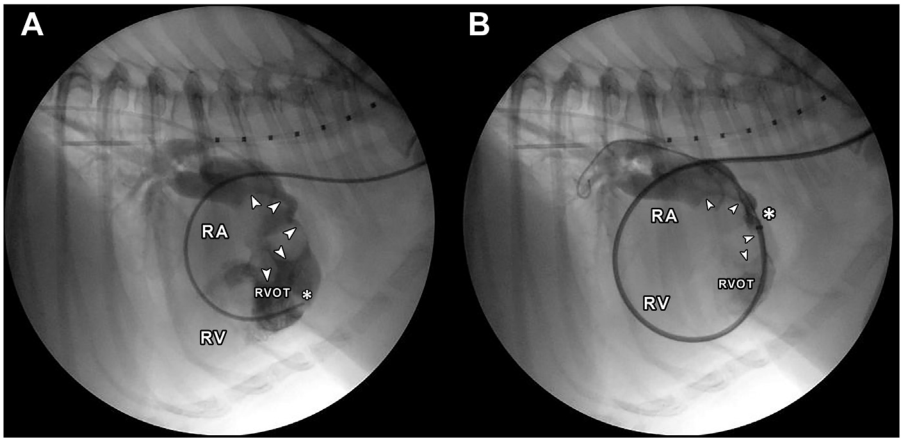

Figure 2 Left lateral selective angiography of the RVOT with a 6-Fr Berman angiographic catheter **(A)** and a 6-Fr guiding sheath **(B)** during systole demonstrating dilation of the RVOT and obstruction of blood flow at the main pulmonary artery caused by a large, intraluminal, trilobed mass (*arrowheads*). In each image, the tip of the catheter is observed (*asterisk*). The dog's head is to the right in these images. A marker catheter used for image calibration is observed in the dog's esophagus. *RA*, Right atrium; *RV*, right ventricle.

been reported as causing stenosis of branch pulmonary arteries, with balloon-expanded and self-expanded vascular stents being used to relieve the obstructions.[13,14] In the dog reported here, compression of the RVOT and main pulmonary artery at the level of the pulmonary valve was observed. Intraluminal invasion was also suspected. This resulted in severe acquired pulmonary stenosis, which was largely resolved acutely with transvalvular pulmonary artery stent implantation. Selective aortic root angiography was performed before stent implantation to better assess coronary arterial blood flow. On the basis of the size of the mass, there was a concern of possible coronary artery compression, which, if present, may have complicated or prevented stent implantation. Additionally, some brachycephalic dogs have

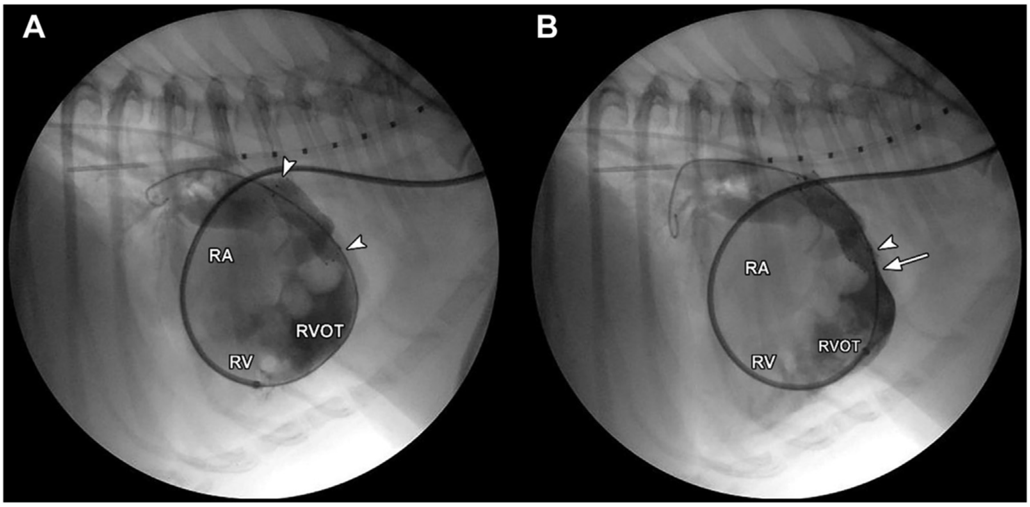

Figure 3 Left lateral selective angiography of the RVOT after implantation of one **(A)** and two **(B)** vascular stents. The proximal and distal extent of the stent that was deployed first (*arrowheads*) and the proximal extent of the stent that was deployed second (*arrow*) are noted. The distal end of the stent that was deployed first is observed at the dorsal-most aspect of the main pulmonary artery (*black arrowhead*). The dog's head is to the right in these images. *RA*, Right atrium; *RV*, right ventricle.

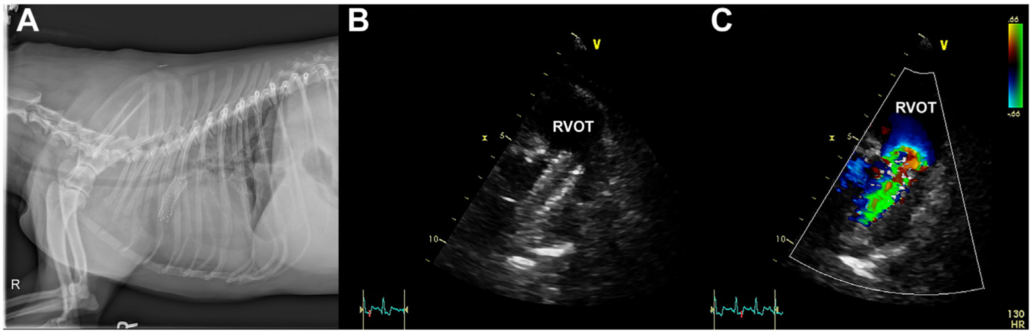

Figure 4 Postoperative thoracic radiography **(A)** and echocardiography **(B, C)** of the vascular stents implanted across the pulmonary valve. **(A)** Right lateral radiograph, with vascular stents identified as bright metallic implants. The dog's head is to the left in this image. **(B)** Right parasternal short-axis view of the vascular stents implanted across the pulmonary valve. **(C)** Color flow Doppler imaging of the right parasternal short-axis view, demonstrating stent patency.

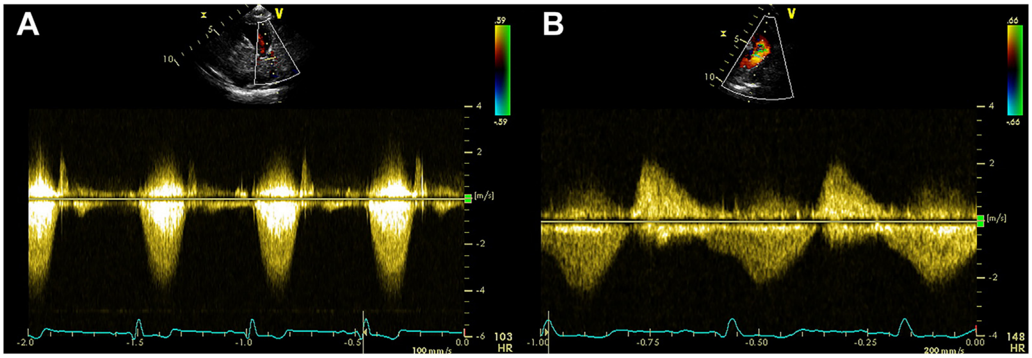

Figure 5 Continuous-wave Doppler interrogation of transpulmonary flow in the right parasternal short-axis views during the preoperative examination **(A)** and postoperative examination **(B)**. An increased amount of pulmonic regurgitation from trivial (preoperative) to moderate (postoperative) is observed, as is expected.

been reported to have coronary aberrancy consisting of a single coronary ostium, which, if present, may have also complicated or prevented stent implantation.[15]

In general, the two types of vascular stents that may be used include balloon-expandable and self-expanding stents.[16,17] Balloon-expandable stents have a relatively high radial force during implantation and may be expanded to a larger diameter subsequently with a larger balloon. Balloon-expandable stents are used in dogs and humans with pulmonary valve stenosis for two main reasons: (1) achieving a high radial force during implantation may be necessary to fully expand the stent against thick, dysplastic pulmonary valve tissue, and (2) subsequent dilation of the stent to account for patient growth may be necessary.[16,17] Self-expanding stents may be delivered through smaller access sheaths and need not be delivered inside a guiding sheath.[16,17] Therefore, self-expanding stents may be optimal for complex stenotic lesions with tortuous anatomy or that are challenging to access.[16] A self-expanding vascular stent was chosen for this dog because of tortuous course of blood flow around the mass and the perceived risk for potential damage that may have occurred to the pulmonary annular wall if a balloon-expandable stent using a high-pressure balloon were used. With the perceived invasion into the main pulmonary artery, it was unknown if the integrity of the pulmonary annular wall had remained normal as the neoplasia grew. Additionally, it was deemed unnecessary to further dilate the stent in the future. The size of the stent was chosen to be the same size as the aortic annular diameter, with the assumption that the aortic annulus and pulmonary annulus were likely similar in size before the growth of the chemodectoma.

CONCLUSION

Transvalvular pulmonary artery stent angioplasty is feasible with acquired pulmonary valve stenosis secondary to heart-base neoplasia. Although an uncommon manifestation of a chemodectoma in dogs, obstruction of blood flow at the main pulmonary artery or branch pulmonary arteries has been documented and should be investigated in dogs with heart-base masses and signs of right-sided congestive heart failure. Long-term benefits from transvalvular pulmonary artery stent implantation in dogs with acquired pulmonary stenosis remain to be seen, but this may be a reasonable option to consider in addition to chemotherapy and radiation therapy in severely affected dogs.

ETHICS STATEMENT

The authors declare that the work described has been carried out in accordance with the ARRIVE guidelines and with the U.K. Animals (Scientific Procedures) Act, 1986 and associated guidelines, EU Directive 2010/63/EU for animal experiments, or the National Research Council's Guide for the Care and Use of Laboratory Animals.

CONSENT STATEMENT

The authors declare that since this was a non-interventional, retrospective, observational study utilizing de-identified data, informed consent was not required from the patient under an IRB exemption status.

FUNDING STATEMENT

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DISCLOSURE STATEMENT

The authors report no conflict of interest.

SUPPLEMENTARY DATA

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