#### **RVC OPEN ACCESS REPOSITORY – COPYRIGHT NOTICE**

This is the author's accepted manuscript of an article published in the Journal of Veterinary Cardiology.

© 2019. This manuscript version is made available under the CC-BY-NC-ND 4.0 license <u>http://creativecommons.org/licenses/by-nc-nd/4.0/</u>.

The full details of the published version of the article are as follows:

TITLE: Surgical management of tricuspid valve stenosis in a dog

AUTHORS: Poppy Bristow, Anne Kurosawa, Virginia Luis Fuentes, Lynda Rutherford, Dan Brockman

JOURNAL: Journal of Veterinary Cardiology

PUBLISHER: Elsevier

PUBLICATION DATE: 26 April 2019 (online)

DOI: 10.1016/j.jvc.2019.04.002



- Surgical valvulotomy for tricuspid valve stenosis in a dog Poppy Bristow MVetMed Anne Kurosawa MVetMed Virginia Luis Fuentes PhD Lynda Rutherford MVetMed Dan Brockman BVSc Royal Veterinary College Address: Queen Mother Hospital for Animals Royal Veterinary College Hawkshead Lane North Mymms United Kingdom AL9 7TA Corresponding author: Poppy Bristow pbristow@rvc.ac.uk Running title: surgical tricuspid valvulotomy

#### 27 Abstract

28 A 2 year 4 month old female neutered Labrador retriever was presented for 29 evaluation right sided congestive heart failure. Echocardiographic examination 30 revealed tricuspid valve dysplasia with only two small orifices in the valve resulting in severe tricuspid stenosis. The dog underwent a right fifth lateral intercostal 31 thoracotomy and surgical tricuspid valvulotomy, under cardiopulmonary bypass. The 32 33 stenosis was relieved by dividing the valve leaflets between the two orifices with 34 continuation to the commissures, creating a 'bi-leaflet' valve. The dog made a good 35 recovery initially with echocardiography at 48 hours after surgery showing a 36 reduction in tricuspid valve E and A wave velocities and pressure half time (from 230 37 ms to to 65 ms). She was discharged five days after surgery with spironolactone, 38 benazepril, pimobendan and clopidogrel. The dog was re-presented two days later having collapsed, with pyrexia, facial swelling and pitting edema on the ventral neck 39 40 and intermandibular region. Investigations did not reveal an underlying cause and 41 the clinical signs resolved with supportive therapy. Two years after surgery the dog 42 was free of clinical signs with normal exercise tolerance and only mild tricuspid regurgitation on echocardiography, with discontinuation of all medications. 43

#### 44 Key Words

45 Canine; tricuspid valve dysplasia; valvulotomy

Abbreviation	Definition
TR	tricuspid regurgitation
TV	tricuspid valve
TVD	tricuspid valve dysplasia

47 A 2 year, 4 month old female neutered Labrador retriever weighing 32.6 kg presented to the Queen Mother Hospital for Animals, Royal Veterinary College, for 48 evaluation of previously diagnosed tricuspid valve dysplasia (TVD) causing clinical 49 50 signs of lethargy, exercise intolerance and cough associated with right sided congestive heart failure. On presentation she was guiet, alert and responsive with a 51 52 heart rate of 128 beats per minute and a respiratory rate of 24 breaths per minute. She had a body condition score of 6/9. The dog was receiving furosemide (1.2 mg/kg 53 g 12 hr), benazepril (0.23 mg/kg g 24 hr), spironolactone (1.8 mg/kg g 24 hr) and 54 pimobendan (0.15 mg/kg g 12 hr). Echocardiographic evaluation<sup>a</sup> with a 5 MHz 55 56 transducer including three dimensional echocardiographic assessment, showed a 57 severely dilated right atrium and restricted tricuspid valve (TV) leaflet motion, with a 58 network of fibrous structures within the right ventricle and two small valve (Fig. 1-3, Supplemental Videos I and II, all videos available in Supplemental Material on-line). 59 Colour flow Doppler showed turbulent diastolic inflow into the right ventricle but no 60 61 tricuspid regurgitation (TR) was detected (Fig. 4, Supplemental Videos III). The TV pressure half time was 230 ms, the TV E velocity 1.35 m/s and the A velocity 2.27 62 m/s, indicative of severe tricuspid stenosis (Fig. 5) [1]. In addition, the mitral valve 63 leaflets were "clubbed" but there was no left atrial enlargement. 64

65

Despite improvement with medication the dog was still lethargic and exercise
intolerant and her owner remained concerned regarding the quality of her dog's life.
Given her echocardiographic findings she was considered at high risk of subsequent
development of atrial fibrillation and progressive right-sided heart failure. The option
of surgical management with a valvulotomy was therefore offered to the owners with

full discussion of the risks. After consideration, her owners elected to proceed withsurgery.

73

Premedication of methadone (0.2 mg/kg intravenously) was administered to the dog and anaesthesia was induced using fentanyl (10 ug/kg), midazolam (0.3 mg/kg) and propofol (1.2 mg/kg) intravenously. A central venous catheter and peripheral arterial catheter were placed and a paravertebral nerve block with 0.2 mL/kg of ropivacaine was performed. The dog was taken to surgery and the carotid artery was exposed through a five centimetre vertical cervical incision and isolated with loose Rummel tourniquets.

A right fifth intercostal thoracotomy was performed. The pericardium was opened 81 and "pericardial basket" sutures placed to expose the heart. The right external 82 83 carotid artery was cannulated with a 14 F arterial cannula. Venous drainage was achieved with two 26 F right angle cannulas placed in the cranial and caudal vena 84 85 cavae through purse-string sutures in the adjacent right atrial myocardium. Cardiopulmonary bypass was initiated and the dog cooled to an oesophageal 86 temperature of 28°C. Rummel tourniquets of umbilical tape were used to form a seal 87 88 around the intracaval part of the venous cannulas and the azygous Rummel was 89 tightened to stop flow through the azygous vein. Umbilical tape was passed around 90 the root of the aorta and an 18 G cardioplegia cannula was inserted into the aortic 91 root through a horizontal mattress suture of 5-0 polypropylene. The aorta was cross-92 clamped distal to the cardioplegia cannula and cold (4°C) cardioplegia solution<sup>b</sup>, combined with blood from the bypass circuit, was infused into the aortic root. 93 94 Cardioplegia was delivered at 20 minute intervals or whenever cardiac muscular 95 activity was observed. A right atrial incision was made along a line parallel with the

96 atrioventricular groove and equidistant from it and the dorsal pericardial reflection of 97 the right atrium, as previously described [2]. Stay sutures of 3-0 polyglactin 910 were placed around the atrial incision to maintain exposure of the tricuspid valve 98 99 orifice. The TV was inspected and had two almost equally sized orifices that were approximately three mm's in diameter and 1.5 cm apart (Fig. 3). Stay sutures of 5-0 100 101 polypropylene were placed at the edges of the rostral valve orifice and the valve 102 leaflets were divided between the two orifices in a cranial to caudal direction, using 103 right angle Potts scissors, taking care not to damage the underlying chordal 104 attachments. The valve was made into a "bicuspid" valve by continuing the incision 105 to the cranial and caudal tricuspid annulus, preserving chordal attachments to each 106 valve edge. During this process, an iatrogenic "cleft" was created in the septal leaflet 107 of the valve and this was repaired using simple interrupted sutures of 6-0 108 polypropylene. Valve leaflet motion was subjectively good following this procedure. 109 There was a small amount of regurgitation when the valve was tested by filling the 110 right ventricle with saline but this was considered to be acceptable. The atrium was closed using 4-0 polypropylene with expanded polytetrafluoroethylene pledgets in a 111 112 continuous mattress suture oversewn by a simple continuous suture, with de-airing 113 performed as the suture was tied. The aortic cross clamp was removed just after 114 atriotomy closure when the dogs oesophageal temperature reached 30°C ventricular 115 fibrillation occurred and normal sinus rhythm was established with one internal 116 defibrillation of 20 joules. Transesophageal echocardiographic evaluation showed mild tricuspid regurgitation and a subjective reduction in diastolic inflow turbulence 117 118 compared to the pre-operative transesophageal echocardiogram.

Total cross clamp time was 50 minutes, bypass time was 120 minutes and surgical
time was 265 minutes. The dog was moved to the intensive care unit where two units

121 of fresh frozen plasma and one unit of packed red blood cells were administered 122 over the next 8 hours. The chest drain was removed 20 hours post-operatively after 123 reduction of fluid to < 1 mL/kg/hour. Clopidogrel therapy (2 mg/kg per os) every 24 124 hours was initiated following chest drain removal. Benazepril (0.23 mg/kg g 24 hr), spironolactone (1.8 mg/kg q 24 hr) and pimobendan (0.15 mg/kg q 12 hr) were 125 126 continued the morning following surgery. The dog recovered from surgery 127 uneventfully initially, with echocardiography at 48 hours post-operatively showing a reduction in TV E and A wave velocities (1 m/s and 0.97 m/s, respectively) and a 128 129 reduction in TV pressure half time to 65 ms. The right atrium had decreased in size 130 and moderate TR was present.

The dog was discharged on day five, however, she collapsed on day seven and was 131 132 taken to her primary care veterinarian where intravenous antibiotics with potentiated 133 amoxicillin were started. She was readmitted to our hospital the same day and on presentation she was pyrexic (40°C), had a heart rate of 120 beats per minute and 134 was lethargic with facial swelling and pitting edema on the ventral neck and 135 136 intermandibular region. Hematology revealed a mild lymphopenia (0.79 x10e9/L, 137 reference range 1-4.8 x10e9/L) and a hematocrit of 23.5% (reference range 37-55%) 138 with strong evidence of red cell regeneration (1+ anisocytosis, macrocytosis and 139 codocytosis as well as rubriocytosis). Biochemistry revealed mild increase in serum 140 bilirubin concentration (3.1 umol/L, reference range 0-2.4 umol/L) but was otherwise 141 within normal limits. Blood cultures were negative and prothrombin time and 142 activated partial thromboplastin time were within normal limits. Echocardiographic 143 examination was unchanged from the previous scan (four days prior) and ultrasound 144 of the neck revealed subjectively reduced flow through the left jugular vein (where the jugular catheter had been placed). The differentials for the dog's cranial caval 145

146 syndrome included compression from a mediastinal bleed from the repaired carotid 147 surgical site or a thrombus in the cranial cava. Intravenous clavulanate potentiated 148 amoxicillin (20 mg/kg q 8 hr) was continued while waiting for blood culture results, 149 along with intravenous fluid therapy consisting of balanced electrolytes (compound 150 sodium lactate) at 2 mL/kg/hr. The facial swelling progressed and thoracic limb 151 swelling developed, along with intermittent lingual cyanosis over the next two days 152 but the dog remained bright and normothermic. Low molecular weight heparin was 153 started at 200 iu/kg SQ g 8 hr for 24 hours, then reduced to 150 IU/kg g 8 hr for a 154 further 72 hours due to the concern for a thrombus in the vena cava at the site of the 155 jugular catheter or one of the bypass cannulas. The dog made a steady recovery 156 with resolution of all edema, and was discharged on the seventh day following re-157 admission (14 days following surgery) with the same dose of pimobendan, 158 benazepril, spironolactone and clopidogrel.

159 The dog was re-examined two months after surgery, and was bright, alert and 160 responsive with a grade II/VI right apical systolic heart murmur, a heart rate of 114 161 beats per minute and a body condition score of 7/9. The owner reported that the dog was normal at home. Echocardiography showed a further reduction in right atrial 162 163 size, and only mild TR. The TV E and A velocities had decreased further to 0.85 m/s and 0.71 m/s, respectively. Mitral valve stenosis was present (mitral valve pressure 164 165 half time 74 ms, normal <50 ms [3]), but there was no enlargement of the left heart 166 chamber dimensions (Supplemental Videos IV and V). Clopidogrel was continued for 167 three months post-operatively and the dog remained on benazepril, spironolactone 168 and pimobendan.

169 At seven months after surgery, she had no reported abnormalities at home and 170 physical examination revealed no change in heart murmur. The right heart chamber 171 dimensions had decreased further with only mild TR present at this time. There was 172 a mild increase in left atrial size (left atrial:aortic annulus 1.8, compared to 1.3 and left atrial diameter in the right parasternal long axis view now 40 mm compared to 37 173 174 mm; Supplemental Video VI). Two and a half years after surgery, the owner reports 175 no clinical signs with normal exercise tolerance. Physical exam reveals no audible 176 murmur on the right and a grade II/VI left apical systolic murmur. The left atrial size 177 and TR is unchanged from the previous visit (considered subjectively mild). The 178 spironolactone, benazepril and pimobendan have been discontinued.

179

#### 180 **Discussion**

To the authors' knowledge, this is the first report of a dog undergoing surgical repair 181 of a dysplastic stenotic TV in the veterinary literature. This dog reported here 182 183 demonstrates that valve surgery may be a feasible treatment option in selected 184 patients with TVD. Both palliative balloon dilation [4,5] and valve replacement [2,6], 185 have been described for the treatment of TV stenosis. The decision to perform a 186 surgical repair in the form of a valvulotomy, rather than to perform balloon dilation or 187 valve replacement was made for a number of reasons. The main concern with 188 balloon dilation of the stenotic valve was the potential for alleviation of stenosis at the 189 expense of severe valvular regurgitation [5]. In addition, we have previously reported 190 poor medium to long term results with TV replacement in dogs with TVD; largely 191 because of acute and chronic thrombus formation, causing valve failure [2]. 192 Furthermore, our growing experience with successful repair of the mitral valve led us

193 to believe that repair of this stenotic TV would give the dog reported here the best 194 chance of a long term solution even in the face of residual valve regurgitation. 195 As expected, TR was present after surgery. This regurgitation was subjectively 196 "moderate" at 48 hours post-operatively and changed over time to "mild" at the three 197 and seven month post-operative echocardiogram. This is most likely a result of a 198 reduction in right atrial size secondary to a reduction in the TV stenosis and 199 consequent reduction in the valve annulus dimensions, enabling improved 200 coaptation of the valve leaflets. 201 The reason this dog developed cranial caval syndrome seven days after surgery, 202 remains unclear. The two main possibilities we considered were: extracaval 203 compression secondary to bleeding into the mediastinum from the surgically repaired 204 carotid cannulation site, or a thrombus in the cranial cava. We were not able to 205 document either using ultrasound examination. Computed tomographic angiography 206 might have helped to identify the cause, but in the light of ongoing clinical 207 improvement, the additional risk and cost associated with this could not be justified. 208 This complication did present a significant therapeutic dilemma however, with the 209 treatment for our two most likely causes being diametrically opposed. If hemorrhage 210 had been the cause, discontinuation of the dog's anticoagulant medications would 211 have been necessary. A thrombus however would require reinstitution of more aggressive anticoagulant therapy. Additional testing such as thromboelastography, 212 213 fibrinogen concentration and d-dimers may have helped to clarify the likelihood of 214 clot formation compared with ongoing bleeding, however, interpretation of such tests would have been difficult given the lack of information regarding the effects of 215 216 cardiopulmonary bypass on these parameters [7,8]. Whilst these tests can help

217	clarify the coagulation status in some cases, they do not confirm the presence of a
218	clot and are no more sensitive to overt bleeding than conventional coagulation
219	analytes such as partial thromboplastin time and activated partial thromboplastin
220	time which were both within normal limits at this time [7,8,9].
221	
222	In conclusion, this case report confirms that TV stenosis can be successfully
223	managed surgically and a degree of TV incompetence may be tolerated well by
224	some dogs for an extended period of time. This report confirms that repair of some
225	forms of TVD is possible and suggests that the repair may not have to be perfect in
226	order to achieve a good clinical outcome.
227	
228	
229	References
230	
231	[1] Shah PM, Raney AA. Tricuspid valve disease. Curr Probl Cardiol 2008;33:47-
232	84
233	[2] Bristow PC, Sargent, JS, Luis Fuentes VL, Brockman DJ. Outcome of
234	bioprosthetic valve replacement in dogs with tricuspid valve dysplasia. J Small
235	Anim Pract 2017;58:205-10
236	[3] Oyama, MA, Weidman JA, Cole SG. Calculation of pressure half-time. J Vet
237	Cardiol 2006;10:57-60
238	[4] Kunze CP, Abbott JA, Hamilton SM, et al. Balloon valvuloplasty for palliative
239	treatment of tricuspid stenosis with right-to-left atrial-level shunting in a dog. J Am

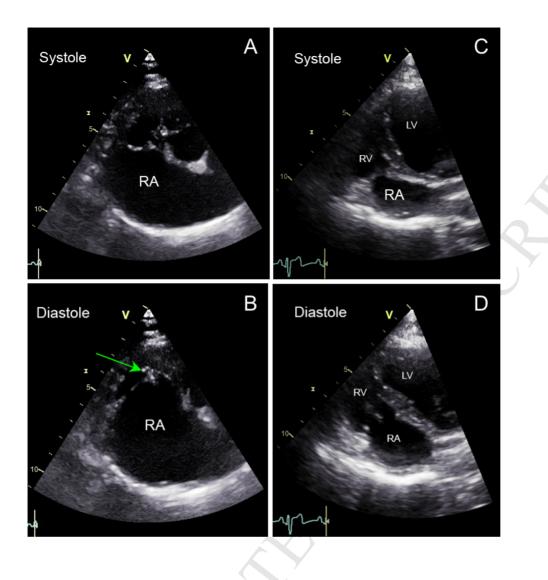
241	[5] Lake-Bakaar GA, Griffiths LG, Kittleson MD. Balloon Valvuloplasty
242	of Tricuspid Stenosis: A Retrospective Study of 5 Labrador Retriever Dogs. J Vet
243	Intern Med 2017;31:311-15
244	[6] Arai S, Griffiths LG, Mama K, Hackett TB, Monnet E, Boon JA, Carter MS,
245	Orton CE. Bioprosthesis valve replacement in dogs with congenital tricuspid valve
246	dysplasia: Technique and outcome. J Vet Cardiol 2011;13:91–9
247	[7] Thawley VJ, Sanchez MD, Drobatz KJ, King LG. Retrospective comparison of
248	thromboelastography results to postmortem evidence of thrombosis in critically ill
249	dogs: 39 cases (2005-2010). J Vet Emerg Crit Care 2016;26:428-36
250	[8] Wiinberg B, Jensen AL, Johansson PI, Rozanski E, Tranholm M, Kristensen
251	AT. Thromboelastographic evaluation of hemostatic function in dogs with
252	disseminated intravascular coagulation. J Vet Intern Med 2008;22:357-65
253	[9] Yoon JU, Cheon JH <sup>,</sup> Choi YJ, Byeon GJ, Ahn JH, Choi EJ, Park JY. The
254	Correlation between Conventional Coagulation Tests and Thromboelastography in
255	Each Phase of Liver Transplantation. Clin Transplant 2019; Epub ahead of print
256	
257	
258	
259	
260	

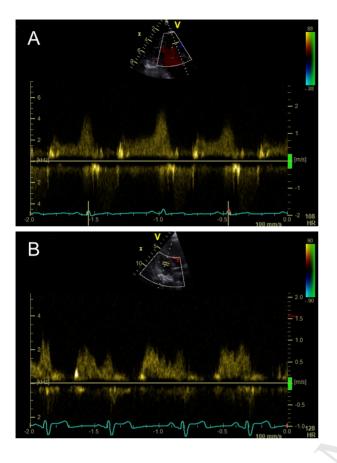
	ACCEPTED MANUSCRIPT	
262		
263	Footnotes	
264	a: Vivid E9, General Electric Medical Systems Ultrasound, Hatfield, UK	
265	b: Cardioplegia infusion, Martindale Pharmaceuticals, Romford, UK	
266		
267 268 269	Figure Captions	
270	Figures 1a and b: Right parasternal long axis view pre- (Fig. 1a) and post-surgery	
271	(Fig. 1b). Pre-surgery the right atrium is severely dilated with the region of valve	
272	leaflet coaptation apically (arrow) displaced. Two months post-surgery there is a	
273	reduction in right atrial size with more normal chamber geometry.	
274		
275	Figures 2a, 2b, 2c, 2d: Left apical views of the tricuspid valve in systole (Figs. 2a and	
276	c) and diastole (Figs. 2b and d) demonstrating reduced opening of the tricuspid	
277	leaflets (arrow) in 2b. Pre-operative images (Figs. 2a and b), post-operative images	
278	(Figs. 2c and d).	
279		
280	Figure 3: Pre-operative three-dimensional echocardiogram showing the two small	
281	orifices in the valve leaflet (green arrows).	
282		
283	Figures 4a and b: Pulsed wave spectral Doppler interrogation of the tricuspid valve	
284	before and after surgery, showing a decrease in pressure half time.	
285		
286	Figure 5: Intraoperative photo showing the two equally sized orifices in the tricuspid	
287	valve, approximately 3 mm in diameter and 1.5 cm apart.	

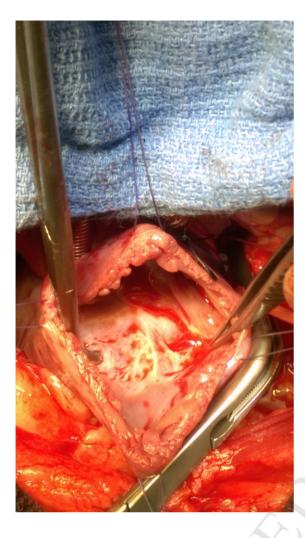
Supplemental Videos	Title	Description	
1	Right parasternal longCR	There is apical displacement	
	axis 4-chamber view	of the area of coaptation of the tricuspid valve leaflets demonstrated	
II	Left apical view	Optimized for the right ventricular inflow, demonstrating abnormal opening of the tricuspid valve leaflets	
	Left apical view	Zoomed to show the tricuspid valve apparatus pre- operatively	
IV	Left apical view	Zoomed view, two months post-operatively, demonstrating improvement in valve motion	
V	Left apical view with color flow Doppler	Two month post-operative view demonstrating resolution of tricuspid	

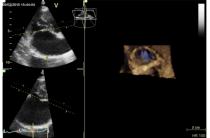
		stenosis
VI	Right parasternal four chamber view	Seven month post-operative view demonstrating maintained reduction in right atrial size

the second second









Contraction of the second

