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Case Report

# Surgical valvulotomy for tricuspid valve stenosis in a dog<sup>☆</sup>



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## KEYWORDS

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**Abstract** A 2-year, 4-month-old neutered female Labrador retriever was brought for evaluation of right-sided congestive heart failure. Echocardiographic examination 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 thoracotomy and surgical tricuspid valvulotomy, under cardiopulmonary bypass. The stenosis was relieved by dividing the valve leaflets between the two orifices with continuation to the commissures, creating a 'bileaflet' valve. The dog made a good recovery initially, with echocardiography at 48 h after surgery showing a reduction in tricuspid valve E and A wave velocities and pressure half-time (from 230 ms to 65 ms). She was discharged five days after surgery, and spironolactone, benazepril, pimobendan, and clopidogrel were prescribed. The dog was re-presented two days later having collapsed, with pyrexia, facial swelling, and pitting edema on the ventral neck and intermandibular region. Investigations did not reveal an underlying cause, and the clinical signs resolved with supportive therapy. Two years after surgery, the dog was free of clinical signs with normal exercise tolerance and only mild tricuspid regurgitation on echocardiography, with discontinuation of all medications.

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<sup>☆</sup> A unique aspect of the Journal of Veterinary Cardiology is the emphasis of additional web-based images permitting the detailing of procedures and diagnostics. These images can be viewed (by those readers with subscription access) by going to <http://www.sciencedirect.com/science/journal/17602734>. The issue to be viewed is clicked and the available PDF and image downloading is available via the Summary Plus link. The supplementary material for a given article appears at the end of the page. Downloading the videos may take several minutes. Readers will require at least Quicktime 7 (available free at <http://www.apple.com/quicktime/download/>) to enjoy the content. Another means to view the material is to go to <http://www.doi.org> and enter the doi number unique to this paper which is indicated at the end of the manuscript.

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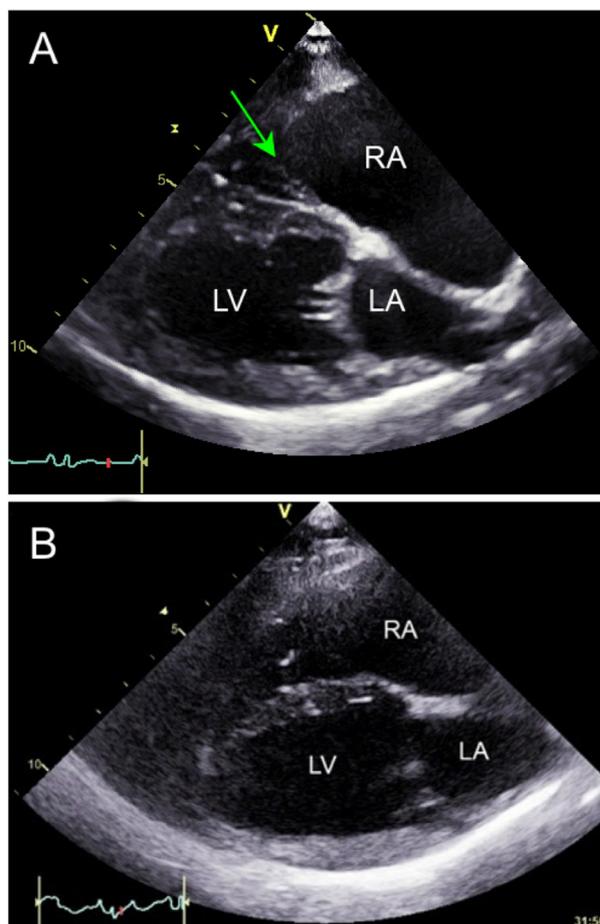
### Abbreviations

TR	tricuspid regurgitation
TV	tricuspid valve
TVD	tricuspid valve dysplasia

A 2-year, 4-month-old neutered female Labrador retriever weighing 32.6 kg presented to the Queen Mother Hospital for Animals, Royal Veterinary College, for evaluation of previously diagnosed tricuspid valve dysplasia (TVD) causing clinical signs of lethargy, exercise intolerance, and cough associated with right-sided congestive heart failure. On presentation, she was quiet, alert, and responsive with a 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 q 12 h), benazepril (0.23 mg/kg q 24 h), spironolactone (1.8 mg/kg q 24 h), and pimobendan (0.15 mg/kg q 12 h). Echocardiographic evaluation<sup>a</sup> with a 5-MHz transducer, including three-dimensional echocardiographic assessment, showed a severely dilated right atrium and restricted tricuspid valve (TV) leaflet motion, with a network of fibrous structures within the right ventricle and two small valve orifices (Figs. 1–3, Supplemental Videos I and II, all videos available in Supplemental Material online). Color flow Doppler showed turbulent diastolic inflow into the right ventricle, but no 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 m/s, indicative of severe tricuspid stenosis (Fig. 5) [1]. In addition, the mitral valve leaflets were ‘clubbed,’ but there was no left atrial enlargement.

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 with surgery.

Premedication of methadone (0.2 mg/kg intravenously) was administered, and anesthesia was

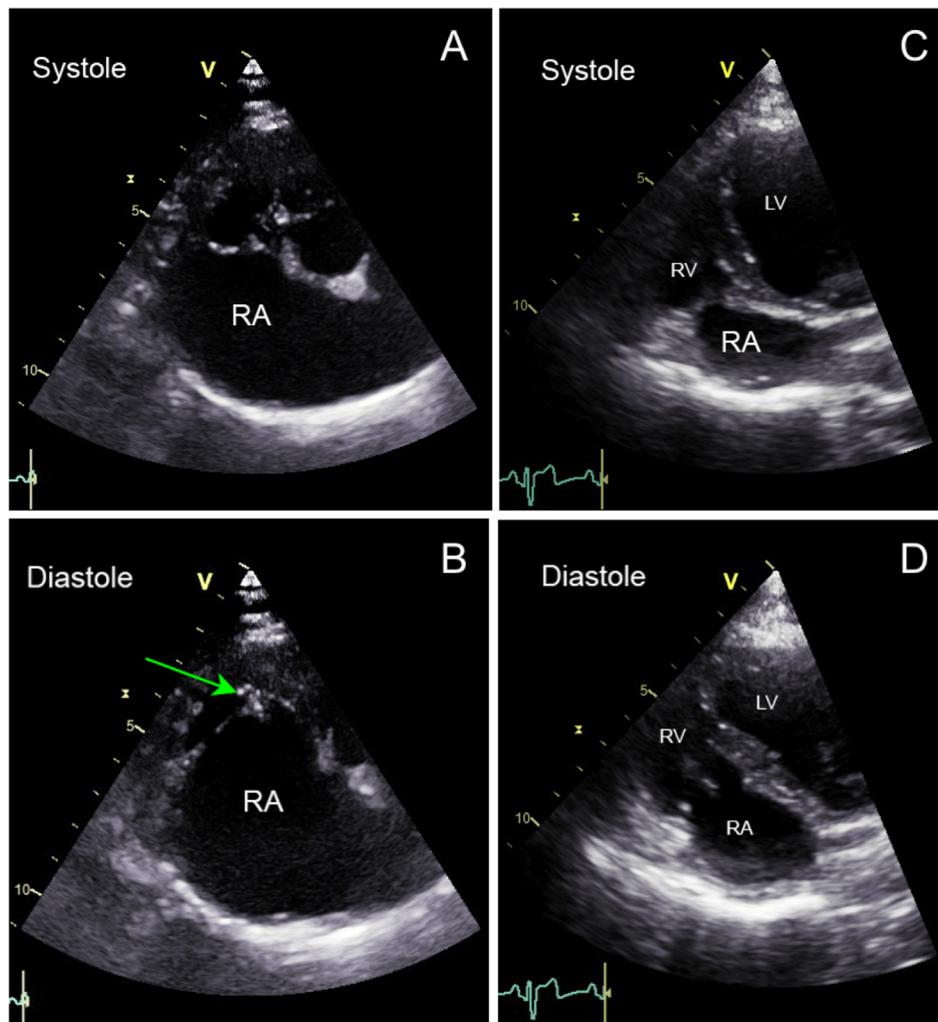


**Fig. 1** : Right parasternal long-axis view before (A) and after surgery (B). Before surgery, the right atrium is severely dilated with the region of the valve leaflet coaptation apically (arrow) displaced. Two months after surgery, there is a reduction in the right atrial size with more normal chamber geometry. RA = Right atrium, LA = left atrium, LV = left ventricle.

induced with fentanyl (10 µg/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-centimeter vertical cervical incision and isolated with loose Rummel tourniquets.

A right fifth intercostal thoracotomy was performed. The pericardium was opened and pericardial basket sutures were placed to increase exposure of the heart. The right external 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 cavae through purse-string sutures in the adjacent right atrial myocardium.

<sup>a</sup> Vivid E9, general electric medical systems ultrasound, Hatfield, UK.

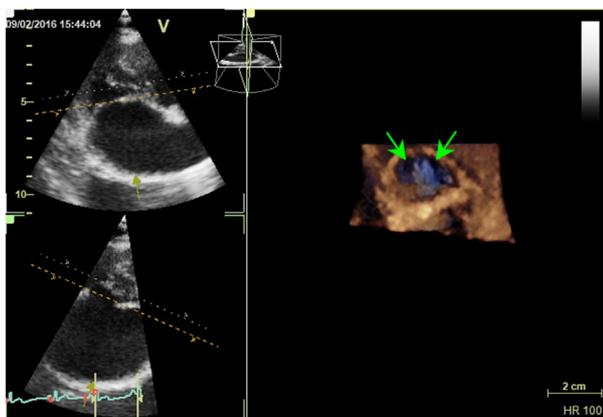


**Fig. 2** Left apical views of the tricuspid valve in systole (A and C) and diastole (B and D) demonstrating reduced opening of the tricuspid leaflets (arrow) in panel B. Preoperative images (A and B) and postoperative images (C and D). RA = right atrium, LV = left ventricle, RV = right ventricle.

Cardiopulmonary bypass was initiated, and the dog was cooled to an esophageal temperature of 28 °C. Rummel tourniquets of umbilical tape were used to form a seal around the intracaval part of the venous cannulas, and the azygous Rummel tourniquet was tightened to stop the flow through the azygous vein. Umbilical tape was passed around the root of the aorta, and an 18-G cardioplegia cannula was inserted into the aortic root through a horizontal mattress suture of 5-0 polypropylene. The aorta was cross-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. Cardioplegia was delivered at 20-min intervals or

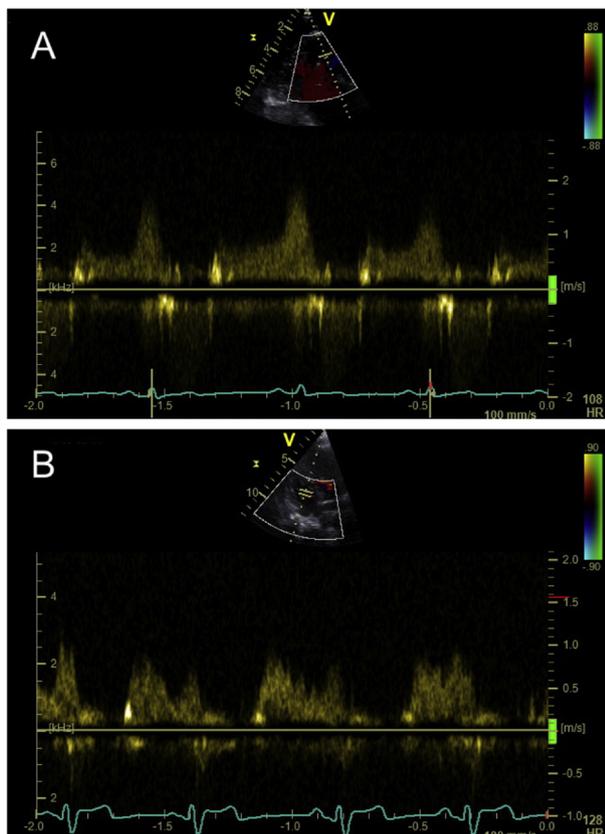
whenever cardiac muscular activity was observed. A right atrial incision was made along a line parallel to the atrioventricular groove and equidistant from it and the dorsal pericardial reflection of the right atrium, as previously described [2]. Stay sutures of 3-0 polyglactin 910 were placed around the atrial incision to maintain exposure of the TV orifice. The TV was inspected and had two almost equally sized orifices that were approximately three mm in diameter and 1.5 cm apart (Fig. 3). Stay sutures of 5-0 polypropylene were placed at the edges of the rostral valve orifice, and the valve leaflets were divided between the two orifices in a cranial to caudal direction, using right-angle Potts scissors, taking care not to damage the underlying chordal attachments. The valve was made into a 'bicuspid' valve by continuing the incision to the cranial and caudal tricuspid annulus, preserving chordal attachments to each valve edge. During

<sup>b</sup> Cardioplegia infusion, martindale pharmaceuticals, Romford, UK.



**Fig. 3** Preoperative three-dimensional echocardiogram showing the two small orifices in the valve leaflet (green arrows).

this process, an iatrogenic cleft was created in the septal leaflet of the valve, and this was repaired using simple interrupted sutures of 6-0 polypropylene. Valve leaflet motion was subjectively good following this procedure. There was a small amount of regurgitation when the valve was tested

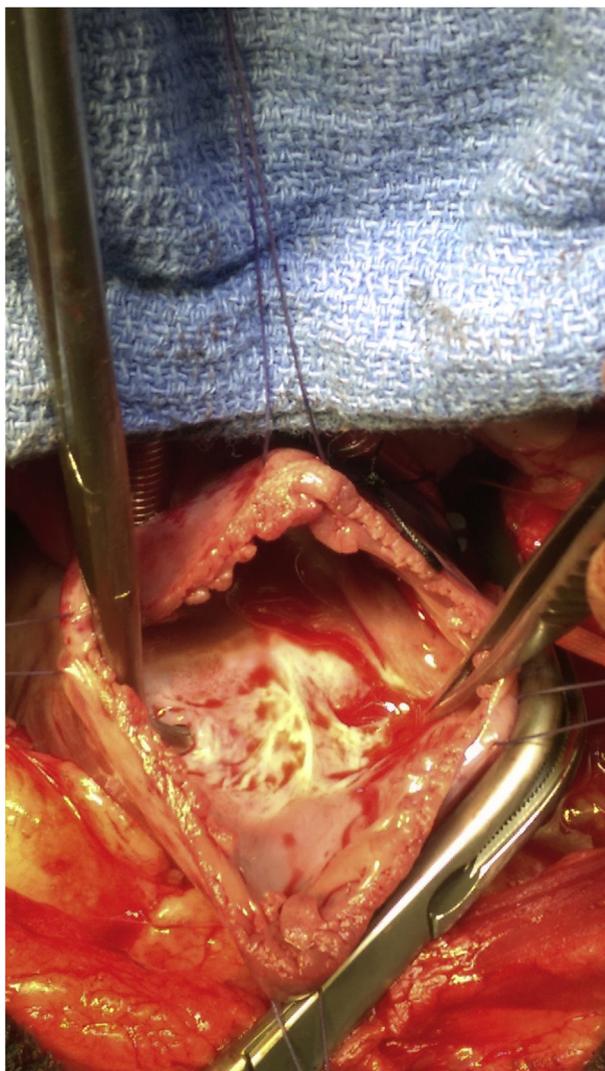


**Fig. 4** Pulsed wave spectral Doppler interrogation of the tricuspid valve before (A) and after (B) surgery, showing a decrease in pressure half-time.

by filling the right ventricle with saline, which was considered to be acceptable. The atrium was closed using 4-0 polypropylene with expanded polytetrafluoroethylene pledgets in a continuous mattress suture oversewn by a simple continuous suture, with de-airing performed as the suture was tied. The aortic cross-clamp was removed just after atriotomy closure when the dog's esophageal temperature reached 30 °C; ventricular fibrillation occurred and normal sinus rhythm was established with one internal defibrillation of 20 J. Transesophageal echocardiographic evaluation showed mild TR and a subjective reduction in diastolic inflow turbulence compared to the preoperative transesophageal echocardiogram.

Total cross-clamp time was 50 min, bypass time was 120 min, and surgical time was 265 min. The dog was moved to the intensive care unit where two units of fresh frozen plasma and one unit of packed red blood cells were administered over the next 8 h. The chest drain was removed 20 h post-operatively after reduction of the fluid to <1 mL/kg/hour. Clopidogrel therapy (2 mg/kg per os) every 24 h was initiated following chest drain removal. Benazepril (0.23 mg/kg q 24 h), spironolactone (1.8 mg/kg q 24 h), and pimobendan (0.15 mg/kg q 12 h) were continued the morning following surgery. The dog recovered from surgery uneventfully initially, with echocardiography at 48 h postoperatively showing a reduction in TV E and A wave velocities (1 m/s and 0.97 m/s, respectively) and a reduction in TV pressure half-time to 65 ms. The right atrium had decreased in size, and moderate TR was present.

The dog was discharged on day five; however, she collapsed on day seven and was taken to her primary care veterinarian where intravenous antibiotics with potentiated 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 was lethargic with facial swelling and pitting edema on the ventral neck and intermandibular region. Hematology revealed a mild lymphopenia ( $0.79 \times 10^9/L$ , reference range 1–4.8  $\times 10^9/L$ ) and a hematocrit of 23.5% (reference range 37–55%), with strong evidence of red cell regeneration (1+ anisocytosis, macrocytosis and codocytosis as well as rubricytosis). Biochemistry revealed mild increase in serum bilirubin concentration (3.1  $\mu\text{mol/L}$ , reference range 0–2.4  $\mu\text{mol/L}$ ) but was otherwise within normal limits. Blood cultures were negative, and prothrombin time and activated partial thromboplastin time were within normal limits. Echocardiographic examination was unchanged from the previous scan (four days



**Fig. 5** Intraoperative photo showing the two equally sized orifices in the tricuspid valve, approximately 3 mm in diameter and 1.5 cm apart.

prior), and ultrasound 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 syndrome included compression from a mediastinal bleed from the repaired carotid surgical site or a thrombus in the cranial cava. Intravenous clavulanate potentiated amoxicillin (20 mg/kg q 8 h) was continued while waiting for blood culture results, along with intravenous fluid therapy consisting of balanced electrolytes (compound sodium lactate) at 2 mL/kg/hr. The facial swelling progressed and thoracic limb swelling developed, along with intermittent lingual cyanosis over the next two days, but the dog remained bright and normothermic. Low-molecular-weight heparin was started at 200 iu/kg SQ q 8 h for 24 h

and then reduced to 150 IU/kg q 8 h for a further 72 h due to the concern for a thrombus in the vena cava at the site of the jugular catheter or one of the bypass cannulas. The dog made a steady recovery with resolution of all edema and was discharged on the seventh day following re-admission (14 days following surgery) with the same dose of pimobendan, benazepril, spironolactone, and clopidogrel.

The dog was reexamined two months after surgery and was bright, alert, and responsive with a grade II/VI right apical systolic heart murmur, a heart rate of 114 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 the right atrial 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 half time 74 ms, normal <50 ms [3]), but there was no enlargement of the left heart chamber dimensions (Supplemental Videos IV and V). Clopidogrel was continued for three months postoperatively, and the dog remained on benazepril, spironolactone, and pimobendan.

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

## Discussion

To the authors' knowledge, this is the first report of a dog undergoing surgical repair of a dysplastic stenotic TV in the veterinary literature. This dog reported here demonstrates that valve surgery may be a feasible treatment option in selected patients with TVD. Both palliative balloon dilation [4,5] and valve replacement [2,6] have been

described for the treatment of TV stenosis. The decision to perform a surgical repair in the form of a valvulotomy, rather than to perform balloon dilation or valve replacement, was made for a number of reasons. The main concern with balloon dilation of the stenotic valve was the potential for alleviation of stenosis at the expense of severe valvular regurgitation [5]. In addition, we have previously reported poor medium- to long-term results with TV replacement in dogs with TVD, largely because of acute and chronic thrombus formation, causing valve failure [2]. Furthermore, our growing experience with successful repair of the mitral valve led us to believe that repair of this stenotic TV would give the dog reported here the best chance of a long-term solution even in the face of residual valve regurgitation.

As expected, TR was present after surgery. This regurgitation was subjectively 'moderate' at 48 h postoperatively and changed over time to 'mild' at the three- and seven-month postoperative echocardiogram. This is most likely a result of a reduction in the right atrial size secondary to a reduction in the TV stenosis and consequent reduction in the valve annulus dimensions, enabling improved coaptation of the valve leaflets.

The reason this dog developed cranial caval syndrome seven days after surgery remains unclear. The two main possibilities we considered were extracaval compression secondary to bleeding into the mediastinum from the surgically repaired carotid cannulation site or a thrombus in the cranial cava. We were not able to document either using ultrasound examination. Computed tomographic angiography might have helped to identify the cause, but in the light of ongoing clinical improvement, the additional risk and cost associated with this could not be justified. This complication did present a therapeutic dilemma, however, with the treatment for our two most likely causes being diametrically opposed. If hemorrhage had been the cause, discontinuation of the dog's anticoagulant medications would have been necessary. A thrombus, however, would require reinstatement of more aggressive anti-coagulant therapy. Additional testing such as thromboelastography, fibrinogen concentration, and d-dimers may have helped to clarify the likelihood of clot formation compared with ongoing bleeding; however, interpretation of such tests would have been difficult, given the lack of information regarding the effects of cardiopulmonary bypass on these parameters [7,8]. While these tests can help clarify the coagulation status in some cases, they do not confirm the presence of a clot and are no more sensitive to overt bleeding

than conventional coagulation analytes such as partial thromboplastin time and activated partial thromboplastin time, both of which were within normal limits at this time [7–9].

In conclusion, this case report confirms that TV stenosis can be successfully managed surgically and a degree of TV incompetence may be tolerated well by some dogs for an extended period of time. This report confirms that repair of some forms of TVD is possible and suggests that the repair may not have to be perfect in order to achieve a good clinical outcome.

## Conflict of Interest Statement

The authors do not have any conflicts of interest to disclose.

## Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jvc.2019.04.002>.

### Video table

Supplemental videos	Title	Description
I	Right parasternal long-axis 4-chamber view	There is apical displacement 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
III	Left apical view	Zoomed to show the tricuspid valve apparatus preoperatively
IV	Left apical view	Zoomed view, two months postoperatively, demonstrating improvement in valve motion

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Supplemental videos	Title	Description
V	Left apical view with color flow Doppler	Two-month postoperative view demonstrating resolution of tricuspid stenosis
VI	Right parasternal four-chamber view	Seven-month postoperative view demonstrating maintained reduction in the right atrial size

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