

Percutaneous balloon valvuloplasty in a small cat with pulmonary valve stenosis and concomitant tricuspid valve dysplasia

H. M. Hipp¹, N. Schreiber¹, M. L. Wieser², N. Pereira³, M. Baron Toaldo¹

¹Division of Cardiology, Clinic for Small Animal Internal Medicine, Vetsuisse Faculty, University of Zurich, Switzerland; ²Section of Anaesthesiology, Department of Clinical Diagnostics and Services, Vetsuisse Faculty, University of Zurich, Switzerland; ³VET Zentrum AG, Switzerland.

Perkutane Ballonvalvuloplastie bei einer kleinen Katze mit Pulmonalklappenstenose und begleitender Trikuspidalklappen-Dysplasie

Eine 14 Monate alte, 3,9 kg schwere, männlich kastrierte Singapurkatze wurde zur Behandlung einer hochgradigen Pulmonalklappenstenose und Trikuspidalklappendysplasie überwiesen. Der Kater wurde mit Atenolol zur folgenden pulmonalen Ballonvalvuloplastie vorbehandelt. Da der Durchmesser der rechten Femoralvene zu gering für eine 5 Fr Einfuhrschleuse war, wurde der Zugang über die linke Jugularvene gewählt, gefolgt von Katheterisierung des rechten Ventrikels, Druckmessung und Angiographie. Ein 10-mm Niederdruckballonkatheter wurde über einen Führungsdraht bis auf Höhe der Pulmonalklappe vorgeschoben. Es wurde eine einzige Ballondilatation durchgeführt, wobei die stenosebedingte Balloneinengung komplett verschwand. Die Katze war vom Zeitpunkt der Katheterisierung des rechten Ausflusstrakts an bis nahezu zum Ende der Narkose über 30 Minuten hochgradig hypotensiv. Eine postoperativ aufgetretene Tachypnoe wurde kongestivem Herzversagen zugeschrieben, eine Aspirationspneumonie konnte jedoch nicht ausgeschlossen werden. Der Patient wurde am Folgetag nach Applikation einer Dosis Furosemid und mit zehntägiger Behandlung mit Amoxicillin-Clavulansäure entlassen. Die echokardiographischen Kontrolluntersuchungen nach elf Tagen, drei Monaten und 16 Monaten ergaben eine deutliche und anhaltende Reduktion des transpulmonalen Druckgradienten. Die Katze zeigte während der 16-monatigen Nachbeobachtungszeit ein anhaltend verbessertes Aktivitätslevel.

Schlüsselwörter: Herz, Echokardiographie, Katze, Intervention, Fehlbildung

Summary

A 14-month-old, male castrated, 3,9-kg Singapura cat was referred for treatment of severe pulmonary valve stenosis associated with tricuspid valve dysplasia. The cat was pre-treated with atenolol and scheduled for pulmonary balloon valvuloplasty. Because the right femoral vein could not accommodate a 5 Fr introducer, vascular access was obtained via the left external jugular vein, followed by right ventricular catheterisation, pressure measurement and angiography. A 10 mm low pressure balloon catheter was advanced over a guidewire to the level of the pulmonary valve and inflated once, resulting in complete loss of the balloon waist. During the procedure, the cat was severely hypotensive for 30 minutes, lasting from the time of catheterisation of the right ventricular outflow tract until nearly the end of anaesthesia. Postoperative tachypnoea was attributed to congestive heart failure, although aspiration pneumonia could not be excluded. The patient was discharged the day after the intervention following a single dose of furosemide and received amoxicillin-clavulanate for ten days. Echocardiography after eleven days, three months and 16 months demonstrated a marked and sustained reduction of the transvalvular pressure gradient. The cat showed an improved activity level after the procedure, which persisted over the 16-month follow-up period.

Keywords: Cardiac, echocardiography, feline, intervention, malformation

<https://doi.org/10.17236/sat00486>

Eingereicht: 18.11.2025
Angenommen: 10.07.2026

Percutaneous balloon
valvuloplasty in a small
cat with pulmonary valve
stenosis and concomitant
tricuspid valve dysplasia

H. M. Hipp, N. Schreiber,
M. L. Wieser, N. Pereira,
M. Baron Toaldo

Introduction

Pulmonary valve stenosis (PS) is one of the most common congenital cardiac defects in dogs.^{12,26,30} In cats, the disease is less frequently observed, accounting for 4% to 10% of the reported congenital defects.^{26,30,34} The few published feline cases exhibited similar morphologic changes of the valvular complex as observed in dogs, ranging from commissural valve fusion to valve dysplasia, with or without pulmonary valve annulus hypoplasia.^{4,7,14,30} Pulmonary valve stenosis increases right ventricular afterload, inducing right ventricular concentric hypertrophy, as a compensatory mechanism. In severe cases, diastolic dysfunction and ventriculo-arterial uncoupling can develop over time, leading to clinical signs, such as exercise intolerance, syncope, congestive heart failure and premature death.^{2,12,17,25}

Tricuspid valve dysplasia (TD) is a slightly more commonly documented cardiac defect in cats (5% to 11% of the reported defects).^{26,30,34} The atrioventricular valve malformation causes incomplete leaflet apposition during systole, resulting in blood regurgitation into the right atrium. In severe cases, right-sided volume overload may develop and progress to right-sided congestive heart failure with pleural effusion and/or ascites.^{5,15}

Pulmonary valve stenosis and TD commonly occur as isolated cardiac defects, but their combination has been reported in cats, dogs and humans.^{6,7,20,29} Serial foetal echocardiographic examinations in humans suggest that reduced pulmonary forward flow, secondary to TD, may be an underlying mechanism for this combination of defects.⁸ Concurrent PS and TD is clinically important because affected patients are more likely to develop right heart dilation and congestive heart failure than those with isolated PS.^{1,12}

Auscultation of a loud murmur in a young cat may raise suspicion for a congenital cardiac defect, but echocardiography is required to establish a diagnosis. It further allows to assess the severity of malformations, identify secondary cardiac remodelling and presence of concurrent defects. This information is required to decide whether a therapeutic intervention is indicated.²⁴ Pulmonary balloon valvuloplasty was first performed in a canine patient in 1980 and has since then become the treatment of choice for most dogs and humans with significant PS.²⁵ To the authors' knowledge, pulmonary balloon valvuloplasty has only been reported in three cats in the veterinary literature.^{9,14}

This report describes the clinical and echocardiographic findings of a cat with PS and concurrent TD that underwent pulmonary balloon valvuloplasty.

Case report

A 14-month-old, male castrated, 3,9-kg Singapura cat was referred for treatment of severe PS. The owner reported that the cat was smaller than its littermates, less energetic, and sleeping more. The disease was diagnosed initially at four months of age with a peak transvalvular flow velocity of 5 m/s (transvalvular pressure gradient [PG]: 100 mmHg), increasing to 5,5 m/s (PG: 121 mmHg) at the time of referral.

On presentation, cardiac auscultation was rhythmic with a loud (4/6) systolic murmur with point of maximal intensity at the left heart base. The remainder of the clinical examination was unremarkable.

Transthoracic echocardiography (Philips EPIQ 7G, Philips AG, Seestrasse 87, 8810 Horgen, Switzerland) was performed with a 12 MHz transducer after administration of butorphanol (Alvegesic® 1% forte ad us. vet., Virbac AG, Postfach 353, 8152 Opfikon, Switzerland, 0,2 mg/kg i.m.). Severe right atrial (maximal right atrial diameter in long axis: 19 mm, reference <12,6 mm) and right ventricular dilation (end-diastolic right ventricular diameter at the level of the tricuspid annulus in long axis: 14 mm, reference <5,7 mm), along with marked thickening of the right ventricular free wall (end-diastolic wall thickness in long axis 4,5 mm, reference <2,7 mm) were noted.²⁸ The left heart appeared mildly hypovolemic (maximal left atrial diameter in long axis: 10,8 mm, reference 13,7-14,5 mm; end-diastolic left ventricular internal diameter in short axis in diastole: 10,5 mm, reference 13,1-14,2 mm), with normal left ventricular free wall thickness (end-diastolic wall thickness in short axis: 3,6 mm).²⁷ The interventricular septum was flattened during ventricular diastole, suggesting increased right ventricular diastolic pressure. A severely shortened, moderately thickened, hypomotile septal tricuspid leaflet, and an elongated parietal tricuspid leaflet with shortened and subjectively thickened chordae tendineae inserting at a hypertrophied papillary muscle were evident (Figure 1: A and B). The pulmonary valve had a restrictive opening during systole, with evidence of systolic doming of the non-thickened leaflets. The pulmonary valve annulus was normally sized (aorta to pulmonary diameter ratio of 7 mm / 6,8 mm = 1,03), and the main and right pulmonary arteries were dilated. Colour Doppler examination showed systolic turbulent blood flow across the pulmonary valve and mild diastolic pulmonary valve insufficiency (Figure 1: C). The transvalvular continuous wave Doppler profile suggested combined presence of fixed and dynamic stenosis with a peak transvalvular flow velocity of 5,6 m/s (PG: 125 mmHg) (Figure 1: D). There was moderate tricuspid valve regurgitation on colour Doppler interrogation, which was attributed to a combination of the tricuspid annulus dilation and tricuspid valve changes. Maximal tricuspid valve regurgitation velocity on continuous wave Doppler was 6,2 m/s (PG: 154 mmHg), with a parabolic profile shape. The final echocardiographic diagnosis was severe PS (type A) and TD.

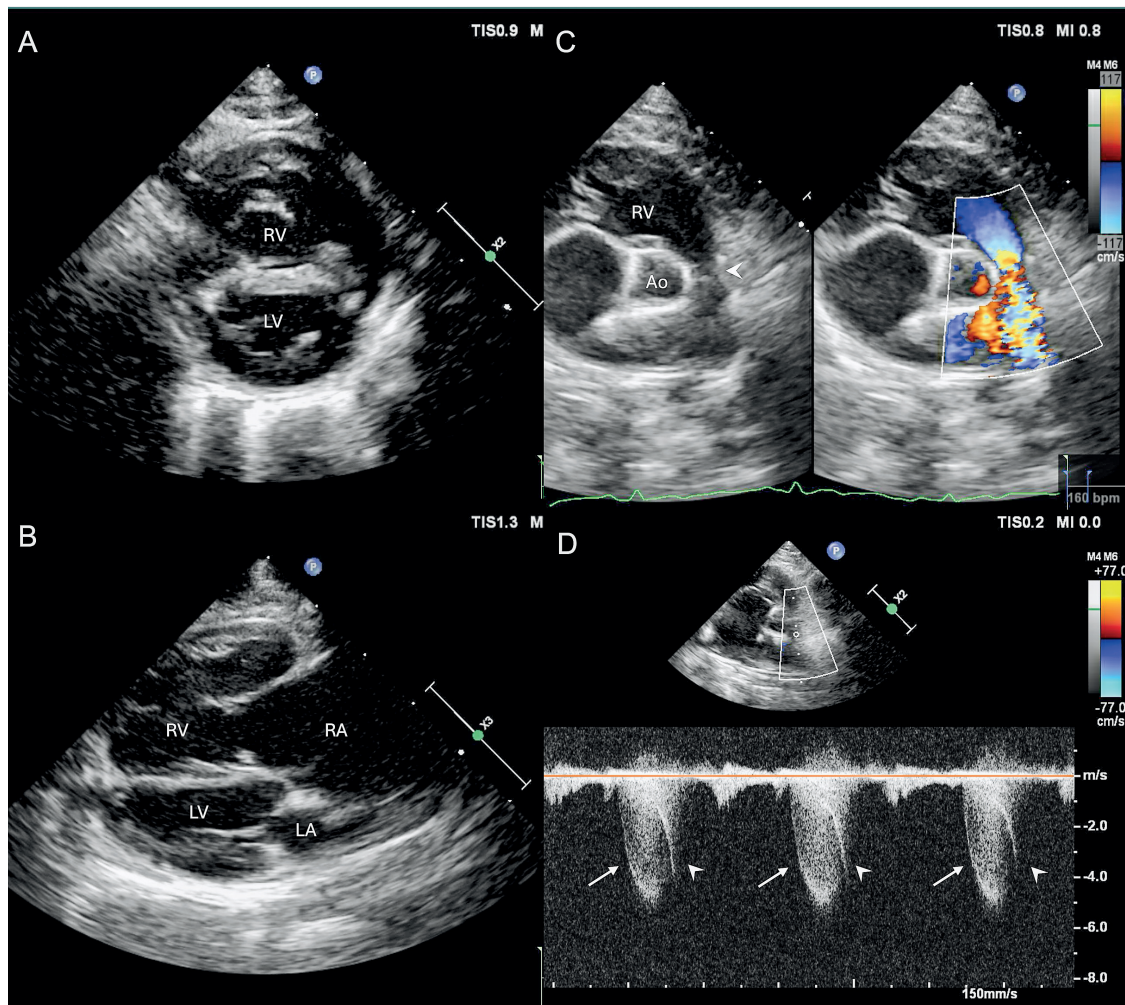


Figure 1: Transthoracic echocardiography of a young Singapura cat with severe pulmonary valve stenosis and tricuspid valve dysplasia one month before balloon valvuloplasty.

A: Right parasternal short axis view at the level of the papillary muscles showing severe right ventricular wall hypertrophy and right ventricular cavity dilation with diastolic flattening of the interventricular septum.

B: Right parasternal long-axis four-chamber view during diastole highlighting the right ventricular mixed hypertrophy and right atrial dilation. The interventricular septum appears flattened during diastole and the left heart is volume depleted. The septal tricuspid valve leaflet is shortened, while the parietal one is thickened with short chordae tendineae.

C: Combined two-dimensional and colour Doppler images at the level of the cardiac base. Notice the turbulent systolic flow across the pulmonary valvular complex (arrowhead at the level of the pulmonary valve) with central narrowing of the jet due to the stenosis. The main pulmonary artery and its right branch show a poststenotic dilation.

D: Continuous wave Doppler transvalvular flow showing the severe stenosis with a fixed ("bullet"-shaped; arrows) and a dynamic ("dagger"-shaped; arrowheads) component with high velocity (above 5 m/s).

Abbreviations: Ao aorta, LA left atrium, LV left ventricle, RA right atrium, RV right ventricle

Treatment with atenolol (Atenolol Mepha® Lactab 25 mg, Mepha Pharma AG, Kirschgartenstrasse 14, 4010 Basel, Switzerland, 6,25 mg sid and increased to bid p.o. after one week) was prescribed in attempt to reduce the dynamic component of the stenosis and the cat was scheduled for pulmonary balloon valvuloplasty. One month later, the patient was sedated intramuscularly with butorphanol (0,3 mg/kg), midazolam (Midazolam Sintetica® 5 mg/1 ml, Sintetica SA, Via Penate 5, 6850 Mendrisio, Switzerland, 0,2 mg/kg), and alfaxalone (Alfaxan® Multidose 10 mg/ml ad us. vet., Dr. E. Graeb AG, Rehhagstrasse 83, 3018 Bern, Switzerland, 1,5 mg/kg). Paediatric external defibrillator

pads were placed bilaterally on the thoracic wall. Anaesthesia was induced with etomidate (Etomidat® Lipuro 2 mg/ml, B. Braun Medica AG, Seesatz 17, 6204 Sempach, Switzerland, 1,5 mg/kg i.v.) and midazolam (0,1 mg/kg i.v.). Following intubation with a 4 mm endotracheal tube, anaesthesia was maintained with sevoflurane and continuous rate infusions of crystalloids (Ringer-Laktat 250 ml, Fresenius Kabi AG, Am Mattenhof 4, 6010 Kriens, Switzerland, 3 ml/kg/h i.v.), butorphanol (0,2 mg/kg/h), dexmedetomidine (Dexdomitor® 0,5 mg/ml, Provet AG, Gewerbestrasse 1, 3421 Lyssach, Switzerland, 0,25–0,5 µg/kg/h), and dopamine (Dopamin 50 mg/5 ml, Fresenius Kabi Austria GmbH,

Percutaneous balloon valvuloplasty in a small cat with pulmonary valve stenosis and concomitant tricuspid valve dysplasia

H. M. Hipp, N. Schreiber, M. L. Wieser, N. Pereira, M. Baron Toaldo

Percutaneous balloon valvuloplasty in a small cat with pulmonary valve stenosis and concomitant tricuspid valve dysplasia

H. M. Hipp, N. Schreiber,
M. L. Wieser, N. Pereira,
M. Baron Toaldo

Hafnerstrasse 36, 8055 Graz, Austria, 6,5-10 µg/kg/min i.v.). Cefazoline (Kefzol®, Teva Pharma AG, Kirschgartenstrasse 14, 4010 Basel, Switzerland, 22 mg/kg q 90 min i.v.) was also given perioperatively. Invasive systemic arterial pressure was continuously recorded. A paediatric transoesophageal echocardiography probe (S7-3t, Philips AG, Seestrasse 87, 8810 Horgen, Switzerland) was inserted into the oesophagus to monitor the procedure. The right femoral vein was surgically isolated and vascular access was attempted using a modified Seldinger technique. However, a 5 Fr vascular introducer (Radifocus® Introducer II, Terumo GmbH, Düsseldorf Strasse 15, 65760 Eschborn, Germany) could not be advanced over the guidewire due to the small size of the vessel. Therefore, the left external jugular vein was then successfully accessed percutaneously using the same technique. The right heart was catheterised under fluoroscopic guidance using a main pulmonary artery catheter (MPA1, Cordis Germany GmbH, Südportal 1, 22848 Norderstedt, Germany). Right ventricular systolic pressure was 135 mmHg. Systemic arterial systolic pressure at that time was 105 mmHg. A monoplane right ventricular angiogram was performed by rapid hand injection of 1 ml/kg of iohexol (Accupaque® 350 mg/ml, GE Healthcare AG, Europa-Strasse 31, 8152 Glattbrugg, Switzerland), showing narrowing at the level of the pulmonary valvular complex with an annulus diameter of 7 mm, presence of tricuspid insufficiency, right atrial dilatation and marked right ventricular hypertrophy with severe dynamic right ventricular outflow tract obstruction (DRVOTO). The assessment of the coronary arteries during the levophase was normal. Subsequently, a soft guidewire (0,018" Stainless Steel Guidewire, Theragenics, Bristol Industrial Way 5203, 30518 Buford, Georgia, United States of America) was advanced through the catheter into the right pulmonary artery branch, after

which the catheter was withdrawn. During this phase, low grade ventricular arrhythmias were observed (single premature complexes, and non-sustained ventricular tachycardia). Systemic mean arterial pressure decreased from 75 to 28 mmHg and remained at this level despite restoration of sinus rhythm. No evidence of pericardial effusion was noted on transoesophageal echocardiography, ruling out cardiac perforation. Two boli of 5 ml/kg of Ringer's lactate were administered, the dose of dopamine infusion was increased from 6,5 to 15 µg/kg/min, sevoflurane was temporarily discontinued and glycopyrrolate (Robinul® 0,2 mg/ml, Esteve Pharmaceuticals GmbH, Hohenzollerndamm 150-151, 14199 Berlin, Germany, 10 µg/kg i.v.) was given. Heart rate transiently increased from 100 to 155 bpm, but blood pressure did not improve, and end-tidal CO₂ decreased from 33 to 21 mmHg. Subsequently, mechanical ventilation and dopamine and dexmedetomidine infusions were discontinued and noradrenaline (Noradrenalin Sintetica® 1 mg/1 ml, Sintetica SA, Via Penate 5, 6850 Mendrisio, Switzerland, 0,5-0,75 µg/kg/min i.v.) was administered. Moreover, a 10 ml bolus of hydroxyethyl starch (Voluven 6% Infusionslösung freeflex® 500 ml, Fresenius Kabi AG, Am Mattenhof 4, 6010 Kriens, Switzerland) was given.

In the meantime, a 10 mm wide low pressure balloon catheter (Veterinary Balloon Catheter 10,0 mm × 3,0 cm × 90 cm, NuMed Inc., 2880 Main Street Hopkinton, NY 12965, United States of America) was advanced over the guidewire to the pulmonary valve (balloon to annulus ratio 1,43). The correct position of the balloon was confirmed using a previously generated roadmap image. The balloon was then inflated to 3,5 atm with an inflation device and a solution of saline and iohexol, resulting in complete loss of the balloon waist (Figure 2: A-C). Given the ongoing hypotension, fur-

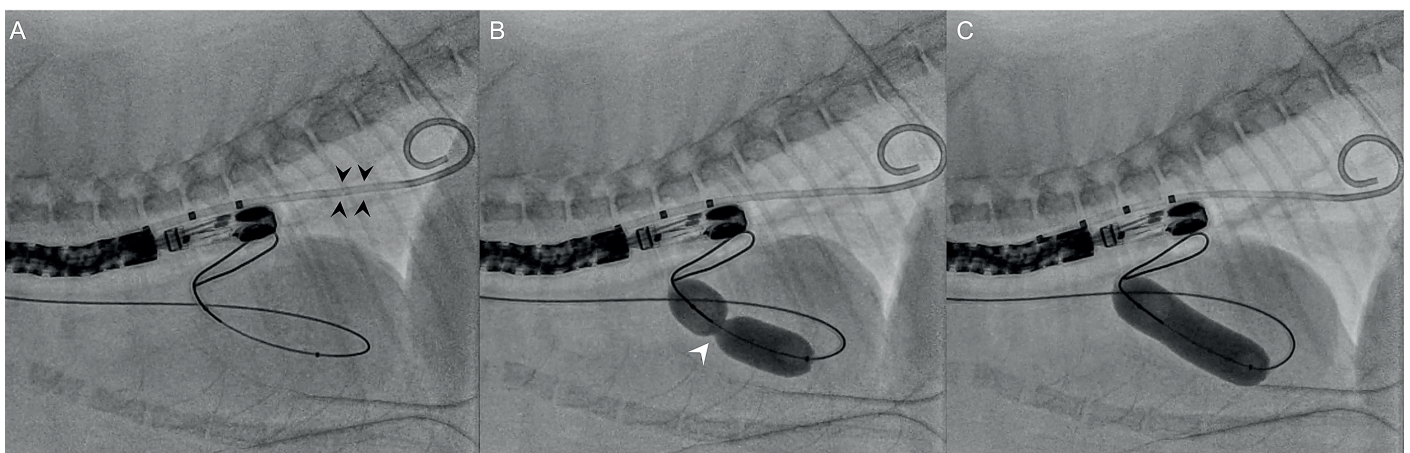


Figure 2: Monoplane fluoroscopy illustrating the pulmonary balloon valvuloplasty procedure in a young Singapura cat with pulmonary valve stenosis. A pigtail marking catheter (black arrowheads) with 1-cm intervals and a paediatric transoesophageal echocardiography probe are present within the oesophagus.

A: A 10 mm wide balloon catheter is inserted via the external jugular vein over a 0,018" guidewire and positioned at the level of the pulmonary valve (radiopaque marker bands visible). The distal part of the wire is located within the right pulmonary artery.

B: Partial balloon inflation shows the balloon waist (white arrowhead), caused by the pulmonary valve stenosis.

C: Fully inflated balloon with complete loss of the balloon waist.

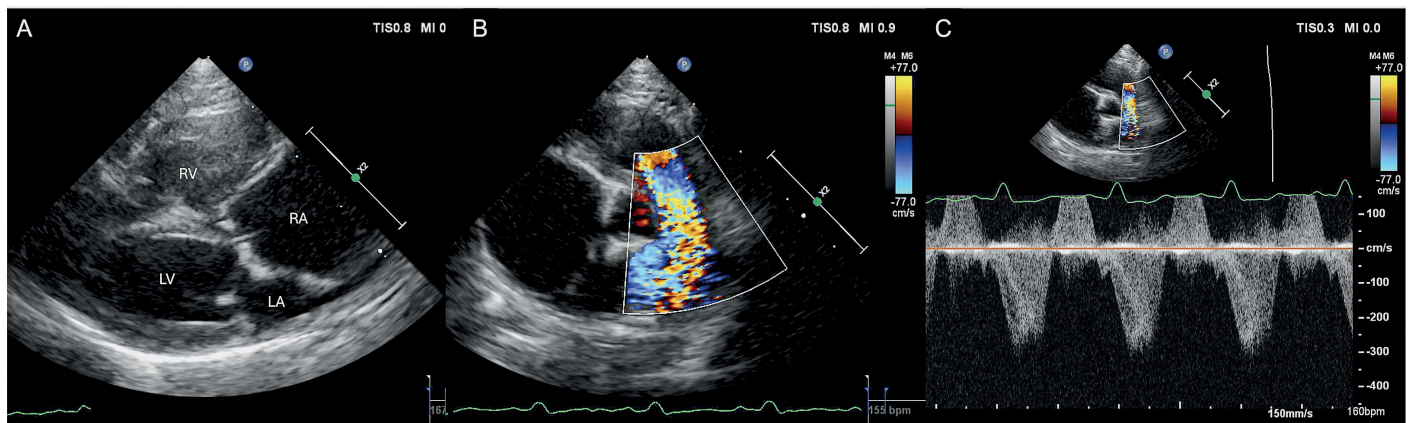


Figure 3: Transthoracic echocardiography of a young Singapura cat with severe pulmonary valve stenosis and tricuspid valve dysplasia eleven days after pulmonary balloon valvuloplasty.

A: Right parasternal long-axis four-chamber view showing better filling of the left heart and absence of interventricular septal flattening.

B: Colour Doppler image of the right ventricular outflow tract. Notice the reduction in systolic flow narrowing across the pulmonary valve complex.

C: Continuous wave Doppler showing a dramatic reduction in peak transvalvular flow velocity (to about 3 m/s). The positive diastolic flow is referable to the pulmonary valve insufficiency.

ther balloon inflations or pressure measurements were not performed, and the balloon catheter and guidewire were promptly retracted. An additional 5 ml bolus of hydroxyethyl starch was administered based on intra-anaesthetic echocardiography demonstrating severe and disproportionate left ventricular underfilling and flattening of the interventricular septum throughout the cardiac cycle. After 30 minutes of hypotension (including 15 minutes after balloon inflation) at a mean systemic arterial blood pressure of 25–30 mmHg, blood pressure normalised to 75 mmHg. A corresponding improvement of left ventricular filling and resolution of systolic septal flattening was evident on echocardiography. The cat was extubated shortly thereafter and recovered in the intensive care unit. The infusion of noradrenaline was gradually tapered and discontinued after a few hours. During the night (approximately six hours after extubation), the cat developed tachypnoea (respiratory rate 84/min), was placed into an oxygen cage and received amoxicillin-clavulanate (Co-Amoxi-Mepha® 550 mg, Mepha Pharma AG, Kirschgartenstrasse 14, 4051 Basel, Switzerland, 20 mg/kg i.v.) because of concerns for aspiration pneumonia. The next day, the cat was alert and responsive but remained mildly tachypnoeic (respiratory rate: 32–36/min). A mild amount of pleural and pericardial effusion, and few B-lines were evident on point-of-care ultrasound and attributed to volume overload during anaesthesia. The cat received a single dose of furosemide (Dimazon® ad us. vet., MSD Animal Health GmbH, Werftstrasse 4, 6005 Luzern, Switzerland, 1 mg/kg i.v.) and was discharged on amoxicillin-clavulanate (Clavaseptin® 62,5 mg ad us. vet., Vetoquinol AG, Freiburgstrasse 255, 3018 Bern, Switzerland, 16 mg/kg tid p.o. for ten days) and atenolol (6,25 mg bid p.o.).

The cat was presented for suture removal eleven days later. On transthoracic echocardiography performed without sedation, the left heart was better filled, and septal flattening

was no longer present (Figure 3: A). The pulmonary valve leaflets appeared to open completely during systole without doming. On colour Doppler examination, the systolic flow across the pulmonary valve was wider (Figure 3: B), with evidence of severe pulmonary valve insufficiency. Peak transvalvular flow velocity was 3,3 m/s (PG: 44 mmHg) (Figure 3: C). The degree of tricuspid insufficiency appeared unchanged compared to before the intervention. Follow-up echocardiography was repeated three and 16 months after the procedure. Therapy with atenolol was discontinued four months after the procedure. Peak transvalvular flow velocity remained low at 3,3 m/s (PG: 44 mmHg) and 3,4 m/s (PG: 46 mmHg), after three and 16 months, respectively. At the 16-month follow-up, right atrial size was regressive (maximal right atrial diameter in long axis: 13 mm). The cat was reported to have shown a sustained increase in activity level after the intervention.

Discussion

The literature on feline PS is limited to few case reports and cross-sectional studies on the prevalence of various congenital heart diseases, including cases of PS.^{5,7,9,14,15,26,30,34} Thus, therapeutic approaches may be guided by the more extensive canine literature. Suggested criteria favouring treatment in dogs include presence of clinical signs, a transvalvular PG of more than 64 mmHg, congestive heart failure, right ventricular systolic dysfunction, and concurrent right-to-left shunts.²⁴ Given the presence of clinical signs, a severely increased transvalvular PG, and the increased risk for congestive heart failure due to concomitant TD with severe right-sided volume overload, a therapeutic intervention was recommended in this patient.

Percutaneous balloon valvuloplasty in a small cat with pulmonary valve stenosis and concomitant tricuspid valve dysplasia

H. M. Hipp, N. Schreiber,
M. L. Wieser, N. Pereira,
M. Baron Toaldo

Therapeutic options for treatment of PS in animals encompass primarily transcatheter interventions, i.e. pulmonary balloon valvuloplasty and stent implantation, while open-heart surgery is only rarely performed.²⁴ Percutaneous pulmonary balloon valvuloplasty is minimally invasive, safe, and effectively reduces the degree of stenosis, associated clinical signs and cardiac related mortality in dogs with significant PS.^{10,16,25} It is known to be most effective in case of commissural leaflet fusion (type A), while a higher probability of residual stenosis and persistent clinical signs is reported for more complex forms characterised by annular hypoplasia (type B).³ In cats, pulmonary balloon valvuloplasty was first reported in 2003, with only two additional cases reported since then.^{9,14} Both of these later reported cats ultimately required stent implantation, either because of a fixed hyperechoic tissue ridge at the sinotubular junction unresponsive to balloon valvuloplasty or due to a dysplastic valve with restenosis after one year. In contrast, in the present case, the valve morphology with systolic leaflet doming and normally sized annulus was considered favourable for balloon valvuloplasty. The selected balloon-to-annulus ratio (1,4) was higher than in the first reported case of the procedure in a cat (1,1, not reported in the other cases), but within the recommended range of 1,3 to 1,5 for dogs.^{9,24}

Advancement of a balloon catheter into the right ventricular outflow tract from the jugular vein can be challenging in small patients because the catheter must undergo extreme (180°) bending within the ventricle.^{13,35} Femoral venous access may reduce this bending angle and was therefore initially attempted.^{11,25} Unfortunately, this approach was impossible due to the small size of the femoral vein. Access was then obtained via the larger left external jugular vein, followed by uncomplicated balloon catheter advancement. Although jugular access has been used for pulmonary balloon valvuloplasty and treatment of other right ventricular outflow tract obstruction in multiple cats, it is possible that the severe right-sided cardiac dilation may have facilitated the advancement of the catheter in our patient.^{18,22,31,32}

The cause of the intraoperative systemic hypotension, which was poorly responsive to multiple interventions, remains undetermined. However, the combination of severe disproportionate left ventricular underfilling and newly present systolic interventricular septal flattening is most compatible with DRVOTO. Unfortunately, pressure gradients across the right ventricular outflow tract were not assessed at the time of hypotension to confirm this hypothesis. Although DRVOTO was evident on angiography at the onset of anaesthesia, it may have worsened at the time of catheterisation of the outflow tract due to mechanical stimulation by the guidewire and catheter, as previously reported.³³ This would lead to underfilling of the left ventricle secondary to reduced right ventricular output and leftward shift of the interventricular septum (ventricular interdependence). Glycopyrro-

late and dopamine increase heart rate and myocardial contractility, potentially worsening the DRVOTO, as suggested by the fact that the cat did not improve after the administration of these drugs.^{21,36} Although mechanical effects of the intracardiac devices, i.e. catheter/wire-induced tricuspid regurgitation and tension of the catheter/wire loop opposing right ventricular contraction may also have contributed to left ventricular hypovolemia, these would be expected to resolve after retraction. Persistence of hypotension following catheter removal could instead suggest ongoing DRVOTO secondary to reduced right ventricular afterload after relief of the valvular stenosis and resulting unopposed right ventricular hypercontractility ("suicide right ventricle").^{25,32} Finally, towards the end of anaesthesia, additional fluid therapy, the vasopressor effect of noradrenaline, and the progressive reduction in vasodilatory anaesthetic concentrations may have increased right ventricular afterload, thereby reducing DRVOTO and improving cardiac output.¹⁹

The postoperative B-lines, effusions and associated tachypnoea are most likely attributable to transient congestive heart failure secondary to intraoperative fluid loading in the context of preexisting severe right-sided cardiac dilation and the impaired right ventricular output described above. Alternative explanations include reperfusion pulmonary oedema, previously reported after pulmonary angioplasty in a cat and after pulmonary balloon valvuloplasty in dogs, as well as pulmonary thromboembolism, aspiration pneumonia, or hemorrhage.^{23,32} A comprehensive postoperative diagnostic evaluation may have identified the cause but was not performed given only mild clinical signs the following day.

Overall, despite these complications, pulmonary balloon valvuloplasty was successful in this patient with a reduction of the transvalvular PG by 63 % at last follow up (>50 % is considered successful in dogs), right atrial reverse remodeling and a sustained improvement in activity level.²⁵ This report supplements the very limited literature on PS in cats and supports the feasibility of pulmonary balloon valvuloplasty in this species.

Valvuloplastie percutanée par ballonnet chez un chat de petite taille présentant une sténose de la valve pulmonaire et une dysplasie concomitante de la valve tricuspide

Un chat Singapura mâle castré, âgé de 14 mois et pesant 3,9 kg, a été présenté pour le traitement d'une sténose valvulaire pulmonaire sévère associée à une dysplasie de la valve tricuspide. Le chat avait reçu un traitement préventif à l'aténolol et une valvuloplastie pulmonaire par ballonnet était prévue. La veine fémorale droite ne pouvant accueillir un introducteur de 5 Fr, un accès vasculaire a été obtenu par la veine jugulaire externe gauche, suivi d'un cathétérisme ventriculaire droit, d'une mesure de la pression et d'une angiographie. Un cathéter à ballonnet basse pression de 10 mm a été avancé sur un fil-guide jusqu'au niveau de la valve pulmonaire et gonflé une seule fois, ce qui a entraîné la disparition complète du rétrécissement du ballonnet. Au cours de l'intervention, le chat a présenté une hypotension sévère pendant 30 minutes, qui s'est prolongée depuis le cathétérisme de la voie d'éjection ventriculaire droite jusqu'à la fin de l'anesthésie. Une tachypnée postopératoire a été attribuée à une insuffisance cardiaque congestive, bien qu'une pneumonie par aspiration n'ait pas pu être exclue. Le patient a pu quitter la clinique le lendemain de l'intervention après l'administration d'une dose unique de furosemide et a reçu un traitement par amoxicilline-clavulanate pendant dix jours. Les échocardiographies réalisées après onze jours, trois mois et seize mois ont montré une réduction marquée et durable du gradient de pression transvalvulaire. Le chat a présenté une amélioration de son niveau d'activité après l'intervention, qui s'est maintenue tout au long de la période de suivi de seize mois.

Mots clés: Cardiaque, échocardiographie, félin, intervention, malformation

Valvuloplastica percutanea con palloncino in un gatto di piccola taglia affetto da stenosi della valvola polmonare e displasia concomitante della valvola tricuspide

Un gatto Singapura di 14 mesi, maschio castrato, del peso di 3,9 kg, è stato riferito alla nostra struttura per il trattamento di una grave stenosi della valvola polmonare associata a displasia della valvola tricuspide. Il gatto è stato sottoposto a pretrattamento con atenololo e programmato per una valvuloplastica polmonare con palloncino. Poiché la vena femorale destra non era in grado di accogliere un introduttore da 5 Fr, l'accesso vascolare è stato ottenuto tramite la vena giugulare esterna sinistra, seguito da cateterizzazione ventricolare destra, misurazione della pressione e angiografia. Un catetere a palloncino a bassa pressione da 10 mm è stato fatto avanzare su un filo guida fino al livello della valvola polmonare e gonfiato una volta, con conseguente perdita completa dell'incisura valvolare del palloncino. Durante la procedura, il gatto ha manifestato grave ipotensione per 30 minuti, che è durata dal momento del cateterismo del tratto di efflusso ventricolare destro fino al termine dell'anestesia. La tachipnea postoperatoria è stata attribuita a insufficienza cardiaca congestizia, sebbene non si potesse escludere una polmonite da aspirazione. Il paziente è stato dimesso il giorno successivo all'intervento dopo una singola dose di furosemide e ha ricevuto amoxicillina-clavulanato per dieci giorni. L'ecocardiografia eseguita dopo undici giorni, tre mesi e 16 mesi ha evidenziato una marcata e sostenuta riduzione del gradiente di pressione transvalvolare. Il gatto ha mostrato un miglioramento del livello di attività dopo la procedura, che è persistito durante il periodo di follow-up di 16 mesi.

Parole chiave: Cardiaco, ecocardiografia, felino, intervento, malformazione

Percutaneous balloon valvuloplasty in a small cat with pulmonary valve stenosis and concomitant tricuspid valve dysplasia

H. M. Hipp, N. Schreiber, M. L. Wieser, N. Pereira, M. Baron Toaldo

Literaturnachweis

- Barger AC, Roe BB, Richardson GS: Relation of valvular lesions and of exercise to auricular pressure, work tolerance, and to development of chronic, congestive failure in dogs. *Am. J. Physiol.* 1952; 169(2): 384–399.
- Borgdorff MAJ, Dickinson MG, Berger RMF, Bartelds B: Right ventricular failure due to chronic pressure load: What have we learned in animal models since the NIH working group statement? *Heart Fail. Rev.* 2015; 20(4): 475–491.
- Bussadori C, DeMadron E, Santilli RA, Borgarelli M: Balloon valvuloplasty in 30 dogs with pulmonic stenosis: Effect of valve morphology and annular size on initial and 1-year outcome. *J. Vet. Intern. Med.* 2001; 15(6): 553–558.
- Chai N, Behr L, Chetboul V, Pouchelon JL, Wedlarski R, Tréhiou-Sechi E, Gouni V, Misbach C, Petit AMP, Bourgeois A, et al.: Successful treatment of a congenital pulmonic valvular stenosis in a snow leopard (*Uncia uncia*) by percutaneous balloon valvuloplasty. *J. Zoo Wildl. Med.* 2010; 41(4): 735–738.
- Chetboul V, Tran D, Carlos C, Tessier D, Pouchelon JL: Les malformations congénitales de la valve tricuspide chez les carnivores domestiques: Étude rétrospective de 50 cas. *Schweiz. Arch. Tierheilkd.* 2004; 146(6): 265–275.
- Formigari R, Francalanci P, Gallo P, D'Offizi F, di Gioia C, Hokayem NJ, D'Alessandro C, Colloridi V: Pathology of atrioventricular valve dysplasia. *Cardiovasc. Pathol.* 1993; 2(2): 137–144.

Percutaneous balloon valvuloplasty in a small cat with pulmonary valve stenosis and concomitant tricuspid valve dysplasia

H. M. Hipp, N. Schreiber,
M. L. Wieser, N. Pereira,
M. Baron Toaldo

- ⁷ Hopper BJ, Richardson JL, Irwin PJ: Pulmonic stenosis in two cats. *Aust. Vet. J.* 2004; 82(3): 143–148.
- ⁸ Hornberger LK, Sahn DJ, Kleinman CS, Copel JA, Reed KL: Tricuspid valve disease with significant tricuspid insufficiency in the fetus: Diagnosis and outcome. *J. Am. Coll. Cardiol.* 1991; 17(1): 167–173.
- ⁹ Johnson MS, Martin M: Balloon valvuloplasty in a cat with pulmonic stenosis. *J. Vet. Intern. Med.* 2003; 17(6): 928–930.
- ¹⁰ Johnson MS, Martin M, Edwards D, French A, Henley W: Pulmonic stenosis in dogs: Balloon dilation improves clinical outcome. *J. Vet. Intern. Med.* 2004; 18(5): 656–662.
- ¹¹ Kadowaki K, Miyashita N, Nakamura K, Mori T: Transfemoral vein approach for balloon pulmonary valvuloplasty in a 1,2-kg dog. *J. Vet. Cardiol.* 2025; 59: 133–138.
- ¹² Kienle RD: Pulmonic stenosis. In: Kittleson MD, Kienle RD (eds.), *Small Animal Cardiovascular Medicine*. Veterinary Information Network, Davis, USA, 2005. <https://www.vin.com/members/cms/project/defaultadv1.aspx?pld=5928&catId=8436> (accessed 25.08.2025)
- ¹³ Kittleson MD: Veterinary Information Network Board: Young cat with pulmonic stenosis: Balloon valvuloplasty vs. medical treatment. 2013. www.vin.com/members/boards/discussionviewer.aspx?documentid=5917368&viewfirst=1&findsince=26280000 (accessed 25.08.2025)
- ¹⁴ Kyan A, Phipps K, Allen J: Transvalvular pulmonary stent angioplasty for palliation of severe pulmonic stenosis in two cats. *J. Vet. Cardiol.* 2026; 64: 48–54.
- ¹⁵ Liu S-K, Tilley LT: Dysplasia of the tricuspid valve in the dog and cat. *J. Am. Vet. Med. Assoc.* 1976; 169(6): 623–630.
- ¹⁶ Locatelli C, Domenech O, Silva J, Oliveira P, Sala E, Brambilla PG, Bussadori C: Independent predictors of immediate and long-term results after pulmonary balloon valvuloplasty in dogs. *J. Vet. Cardiol.* 2011; 13(1): 21–30.
- ¹⁷ Margey R, Inglessis-Azuaje I: Percutaneous therapies in the treatment of valvular pulmonary stenosis. *Interv. Cardiol. Clin.* 2012; 1(1): 101–119.
- ¹⁸ McDevitt H, Stauthammer C, Leeder D, Hanson M, Olson J, Gruenstein D: Palliative balloon angioplasty in a cat with right pulmonary arterial branch stenoses and concurrent absence of the left pulmonary artery. *J. Vet. Cardiol.* 2013; 15(3): 211–216.
- ¹⁹ Munirathinam GK, Kajal K, Jayant A, Dogra N, Singh H: Epicardial echocardiography as rescue modality for detection of dynamic right ventricular outflow tract obstruction in post pulmonary valve stenosis repair. *AA Pract.* 2019; 13(10): 396–398.
- ²⁰ Navarro-Cubas X, Palermo V, French A, Sanchis-Mora S, Culshaw G: Tricuspid valve dysplasia: A retrospective study of clinical features and outcome in dogs in the UK. *Open Vet. J.* 2017; 7(4): 349–359.
- ²¹ Pascoe PJ, Ilkiw JE, Pypendop BH: Effects of increasing infusion rates of dopamine, dobutamine, epinephrine, and phenylephrine in healthy anesthetized cats. *Am. J. Vet. Res.* 2006; 67(9): 1491–1499.
- ²² Ryave J, Sanders RA, Gunasekaran T: Successful balloon angioplasty in a cat with unilateral left pulmonary artery branch stenosis. *J. Vet. Cardiol.* 2023; 50: 17–22.
- ²³ Santarelli G, Bouvard J, Brethel SF, Gordon S, Lord S, Mavropoulou A, Oliveira P, Sykes KT, Swift S, Culshaw GJ: Non-cardiogenic pulmonary oedema complicating balloon valvuloplasty and stent angioplasty of severe pulmonary valve stenosis in four dogs. *J. Vet. Cardiol.* 2022; 39: 79–88.
- ²⁴ Scansen BA: Advances in the Treatment of Pulmonary Valve Stenosis. *Vet. Clin. North Am. Small Anim. Pract.* 2023; 53(6): 1393–1414.
- ²⁵ Scansen BA: Pulmonary valve stenosis. In: Weise C, Berent A (eds.), *Veterinary Image-Guided Interventions*. John Wiley and Sons Inc., Hoboken, USA, 2015: 575–87.
- ²⁶ Scansen BA, Cober RE, Bonagura JD: Congenital heart disease. In: Bonagura JD, Twedt DC (eds.), *Kirk's current veterinary therapy XV*. Elsevier Saunders, Missouri, USA, 2014: 756–757.
- ²⁷ Schober KE, Savino S, Yildiz V: Reference intervals and allometric scaling of two-dimensional echocardiographic measurements in 150 healthy cats. *J. Vet. Med. Sci.* 2017; 79(11): 1764–1771.
- ²⁸ Schober KE, Savino SI, Yildiz V: Right ventricular involvement in feline hypertrophic cardiomyopathy. *J. Vet. Cardiol.* 2016; 18(4): 297–309.
- ²⁹ Schoebel J, Wess G, Tursi M: Histological evidence of myxomatous tissue in a Labrador puppy with pulmonic stenosis and tricuspid valve dysplasia. *J. Vet. Cardiol.* 2025; 62: 45–51.
- ³⁰ Schroppe DP: Prevalence of congenital heart disease in 76,301 mixed-breed dogs and 57,025 mixed-breed cats. *J. Vet. Cardiol.* 2015; 17(3): 192–202.
- ³¹ Schroppe DP: Primary pulmonic infundibular stenosis in 12 cats: Natural history and the effects of balloon valvuloplasty. *J. Vet. Cardiol.* 2008; 10(1): 33–43.
- ³² Schroppe DP, Tyrrell WD, Jacob KA: Successful balloon angioplasty of pulmonary artery stenosis in two cats and associated complications. *J. Vet. Cardiol.* 2017; 19(6): 530–537.
- ³³ Singhal A, Kumar S, Kapoor A: Sudden iatrogenic suicidal right ventricle. *Indian Heart J.* 2015; 67(4): 406–408.
- ³⁴ Tidholm A, Ljungvall I, Michal J, Häggström J, Höglund K: Congenital heart defects in cats: A retrospective study of 162 cats (1996–2013). *J. Vet. Cardiol.* 2015; 17: S215–S219.
- ³⁵ Uemura A, Sejirow G, Tanaka R, Kocaturk M, Yilmaz Z: Transoesophageal echocardiography-guided hybrid balloon valvuloplasty for severe pulmonic stenosis in small dogs. *J. S. Afr. Vet. Assoc.* 2021; 92: 1–5.
- ³⁶ Zeng YH, Calderone A, Rousseau-Saine N, Elmi-Sarabi M, Jarry S, Couture ÉJ, Aldred MP, Dorval JF, Lamarche Y, Miles LF, et al.: Right ventricular outflow tract obstruction in adults: A systematic review and meta-analysis. *CJC Open.* 2021; 3(9): 1153–1168.

Korrespondenzadresse

Marco Baron Toaldo
Division of Cardiology,
Clinic for Small Animal Internal Medicine
Vetsuisse Faculty, University of Zurich,
Winterthurerstrasse 260
8057 Zurich, Switzerland
E-Mail: marco.barontoaldo@uzh.ch