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Case Report

Transjugular patent ductus arteriosus occlusion in a cat using the Vet-PDA Occluder™ device☆

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Abstract A 5-month-old, female, entirely domestic short-haired cat was referred for evaluation of a continuous heart murmur. No associated clinical signs were reported. Transthoracic echocardiography revealed a large, left-to-right shunting patent ductus arteriosus (PDA). Transjugular occlusion of the defect was achieved using a Vet-PDA Occluder™ device, a new conic-shaped nitinol spiral device designed for PDA closure in small-sized dogs weighing less than 3 kg. Resolution of the continuous heart murmur was identified after device deployment. This case report demonstrates that the Vet-PDA Occluder™ can be a feasible option in feline patients for the occlusion of PDA and describes the technique step by step.

Abbreviations: PDA, patent ductus arteriosus.

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A 5-month-old, female, entirely domestic shorthaired cat was presented for further investigation of a suspected congenital cardiac defect. No associated clinical signs were reported. On presentation, the cat was bright, alert, and responsive. Cardiac auscultation revealed a grade V/VI left basilar continuous heart murmur. Thoracic radiographs identified cardiomegaly, with a vertebral heart score of 9.6 (normal reference interval: 7.5 ± 0.3 vertebrae) [1]. Transthoracic echocardiography[e] revealed mild left atrial dilation and moderate left ventricular dilation. Ventricular wall thickness and systolic function were within normal limits (Table 1). A large, left-to-right shunting patent ductus arteriosus (PDA) canine angiographic type-IIB [2] with an average minimal ductal diameter of 1.4 mm and an average ampulla diameter of 5.0 mm (Fig. 1, Video 1) was suspected. Colour flow and spectral Doppler analysis confirmed the presence of continuous blood flow entering the main pulmonary artery and proximal to the left pulmonary branch junction, with an estimated systolic and diastolic pressure gradient of 100 and 30 mmHg, respectively. Transvenous PDA occlusion using a Vet-PDA Occluder™ device[f] (Fig. 2) was recommended to prevent the development of congestive heart failure in the future.

Surgical procedure was performed two weeks after the initial diagnosis. Premedication was performed with intravenous methadone (0.2 mg/kg, intravenous IV). General anaesthesia was induced with alfaxalone (1.5 mg/kg, IV) and maintained with inhaled isoflurane. Prophylactic antibiotic therapy with amoxicillin (22 mg/kg, IV) was administered during the patient's induction.

Following aseptic preparation, the right jugular vein was punctured percutaneously by the Seldinger technique using a 4-French (Fr) micro introducer,[g] followed by a 6-Fr introducer sheath.[h] A 0.035" angled-tip hydrophilic-coated guidewire[i] was advanced without catheter assistance through the right side of the heart and into the main pulmonary artery under fluoroscopic guidance.[j] The guidewire was then extended across the pulmonic valve and ductal opening into the descending aorta. A 4-Fr catheter[k] was advanced over the guidewire and positioned in the descending aorta close to its junction with the PDA ampulla. Occasional premature ventricular complexes were detected when the catheter was placed into the right ventricle. Angiocardiography via manual injection was performed by injecting 1 mL/kg of contrast agent[l] diluted with intravenous isotonic fluid saline in a 1:1 ratio. A large type IIB PDA (Fig. 3) (based on angiographic classification) [2] with an estimated ampulla diameter of 5.2 mm and a minimal ductal diameter of 1.6 mm was visualised. A 6 × 5-mm (distal x proximal coil diameter) Vet-PDA Occluder™ device was considered suitable for this patient. The appropriate size of the occluder was based on the distal and proximal diameters of the device, no more than 2 mm larger than the estimated ampulla diameter and between 3 to 4 mm larger than the estimated pulmonary ostium diameter, respectively.

The first two loops of the device were released into the descending aorta. The catheter was subsequently pulled back into the mid-portion of the ductal ampulla. Three more loops were then released acquiring a conical shape, and the last 1—1.5 loops were left within the catheter. The released loops as well as the catheter were then gently pulled back into the pulmonary ostium, and the proximal loops were positioned in the pulmonary side of the PDA (Video 2). Release of the occluder was performed without applying excessive traction to the device to avoid device dislodgement into the pulmonary artery. Resolution of the continuous heart murmur was identified via auscultation. Transthoracic echocardiography was performed, and residual ductal flow was observed across the central area of the device. Based on the manufacturer's recommendations, device

[e] Affiniti 70 Diagnostic Ultrasound System, Philips Medical Systems, Best, The Netherlands.
[f] Vet-PDA Occluder™, EVOMED, S.L.U., Madrid, Spain.
[g] Micro Introducer Kit (4 Fr), Infiniti Medical, Redwood City, CA, USA.
[h] Intradyn art. Coro W J3 wire F6, BBraun, Melsungen, Germany.
[i] Angled-tip hydrophilic coated guidewire (0.035 inch), Terumo Europe N.V., Leuven, Belgium.
[j] BV Pulsera, Philips Medical Systems, The Netherlands.
[k] Vet-PDA Delivery Catheter (4 Fr; 45 cm), EVOMED, S.L.U., Madrid, Spain.
[l] Omnipaque™ (iohexol) Injection (300 mg/mL), GE Healthcare Inc, Marlborough, MA, USA.

Table 1 Echocardiographic parameters depicting left-sided cardiomegaly secondary to a large left-to right shunting patent ductus arteriosus at initial presentation, one week, and three months after occlusion of the defect.

	Reference range [15]	Initial presentation	One week after occlusion	Three months after occlusion
LVIDd (mm)	11.4—17.8	19.4	19.2	19.0
LVIDs (mm)	5.1—11.7	12.4	12.1	14.4[a]
IVSd (mm)	2.7—4.7	3.4	3.2	3.2
LVPWd (mm)	2.6—4.5	3.5	3.7	3.7
LA:Ao	0.86—1.42	1.75	1.6	1.3
FS (%)	28—62	36.1	37	24[a]

FS: fractional shortening; IVSd: interventricular septal thickness at end-diastole; LA:Ao: ratio of the left atrial dimension to the aortic annulus dimension; LVIDd: left ventricular internal dimension at end-diastole; LVIDs: left ventricular internal dimension at end-systole; LVPWd: left ventricular posterior wall thickness at end-diastole.

[a] Systolic function parameters were unreliable in this case as the animal had to be sedated with dexmedetomidine to perform the echocardiographic study.

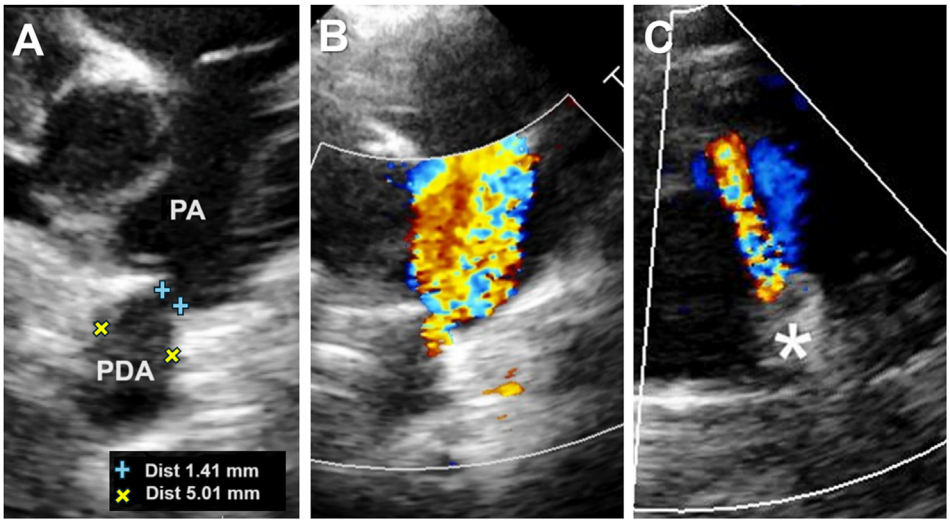

Figure 1 Echocardiographic images: (A) Right parasternal short-axis view at the level of the pulmonary artery: visualisation of the PDA with a minimal ductal diameter of 1.41 mm and an ampulla diameter of 5.01 mm. (B) Colour Doppler mapping (same view): continuous blood flow from the aorta to the pulmonary artery through the PDA. (C) Colour Doppler mapping (same view): minimal residual blood flow through the central part of the device (asterisk). PA: pulmonary artery; PDA: patent ductus arteriosus.

positioning was considered appropriate. Thus, the device was released with gentle manipulation while avoiding excessive traction. Finally, all catheters were removed, and haemostasis was achieved by applying digital pressure to the surgical site for ten minutes. No significant complications were reported. Total procedure time was one hour.

Thoracic radiography after the procedure confirmed adequate device placement (Fig. 4). Despite the resolution of the heart murmur, minimal residual blood flow through the central part of the device was detected by transthoracic echocardiography (Fig. 1, Video 3). The patient was discharged the day after with a 10-day course of oral amoxicillin-clavulanic acid (22 mg/kg, PO, q: 12 h) and pregabalin (5 mg/kg, PO, q: 8 h). Follow-up one week after the procedure revealed persistent resolution of the heart murmur. Transthoracic echocardiography confirmed no significant changes in left ventricular diameter. Follow-up after 3 months showed a reduction in the left ventricular internal dimension at end-diastole as well as a reduction of the left atrial-to-aortic annulus ratio (Table 1). Mild residual blood flow was still present.

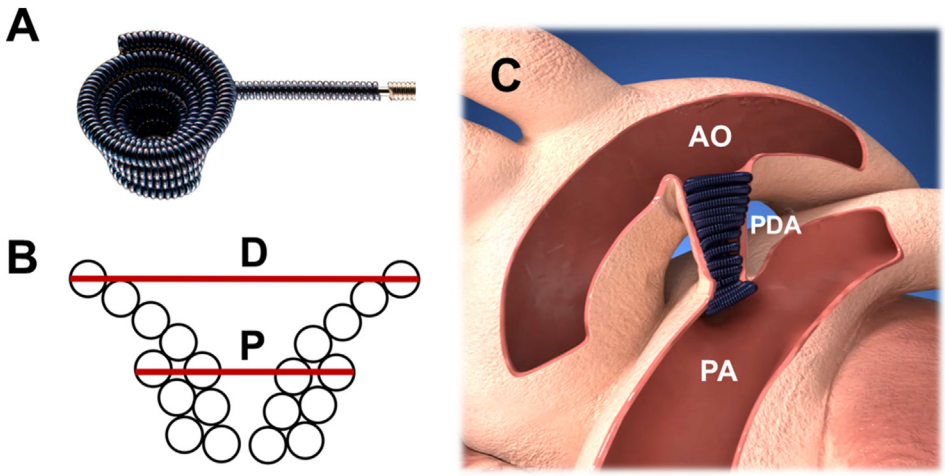

Figure 2 Vet-PDA Occluder™ device: (A) Tight and compact loops enhancing efficient occlusion. (B) Coil dimensions. (C) Drawing of the occlusion device after release (images courtesy of EVOMED). AO, aorta; D, distal diameter; P, proximal diameter; PA: pulmonary artery; PDA: patent ductus arteriosus.

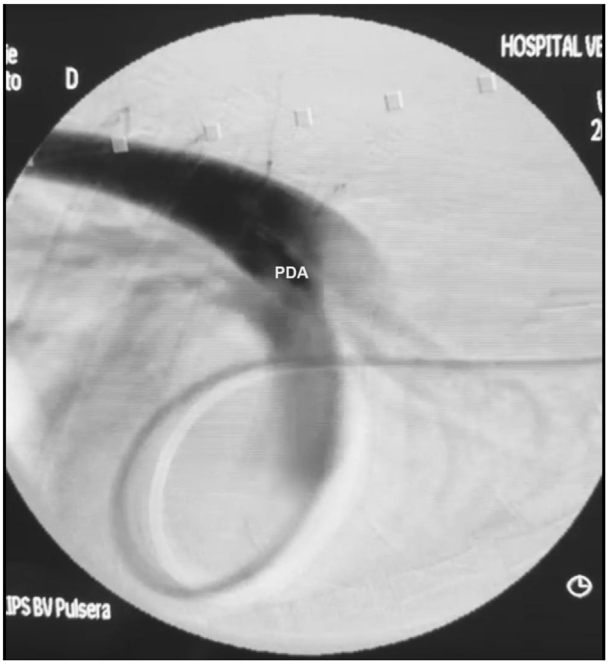

Figure 3 Intraoperative angiographic image: a large type IIB PDA can be seen. The catheter is positioned in the descending aorta just proximal to its junction with the PDA ampulla. PDA: patent ductus arteriosus.

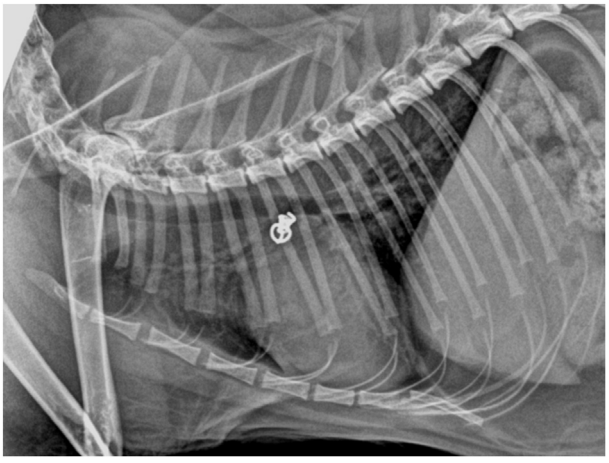

Figure 4 Lateral thoracic radiograph following the procedure and confirming adequate placement and location of the Vet-PDA Occluder™ device.

Discussion

Although PDA is one of the most common congenital cardiovascular defects in the dog (11.1%—17%) [3,4], this pathology is infrequently reported in the cat (3%—5%) [4,5]. A PDA is caused by the failure of the ductus arteriosus to close at birth, leading to volume overload of the left atrium and ventricle, eccentric hypertrophy of the left side of the heart, cardiac chamber remodelling, aortic arch enlargement, and ultimately pulmonary hypertension and/or congestive heart failure.

Definitive therapy involves occlusion of the PDA. Although traditionally intrathoracic surgical ligation via thoracotomy has been the most common approach in cats, the use of minimally invasive intra-arterial catheter-based occlusion devices and their associated advantages, shorter

hospitalisation time, reduced postoperative morbidity, and similar success rate to traditional surgery, have gained recognition in small-sized dogs and cats [6]. In the canine patient, the Amplatz® canine duct occluder,[m] a nitinol mesh device placed through a femoral artery approach, is the device most often used. In the feline patient, however, the small size of the femoral artery in conjunction with the possible development of reflex vasoconstriction secondary to direct manipulation of the blood vessels during surgical or interventional procedures [6,7] precludes the use of minimally invasive techniques via the transarterial approach. Thus, surgical ligation via thoracotomy continues to be the most common procedure for PDA closure in the cat [6].

To avoid size limitation in small dogs (body weight less than 3 kg), other surgical techniques using a transvenous approach have been described. For instance, the use of transvenous retrograde Amplatzer® duct occluder[n], Amplatzer® vascular plug,[o] or Flipper™ detachable embolisation coils[p] via the femoral vein [8,9] as well as transvenous closure using the Nit-Occlud® coil[q] [10] or Vet-PDA Occluder™[r] have been reported with good outcomes and a success rate of up to 96.4% (54/56 small-breed-sized dogs) [8]. The transvenous approach is the preferred technique used in human medicine (particularly in neonates) due to its low complication rates [11]. Similarly, procedures reported in cats include transjugular occlusion using the Amplatz® canine duct occluder device [7], transvenous embolisation with detachable coils [12], transjugular occlusion using the Amplatzer® vascular plug [13], and transvenous closure using the Nit-Occlud® coil [10].

Since the Vet-PDA Occluder™ is a new cone-shaped nitinol spiral device specifically designed for PDA closure in small-sized dogs weighing less than 3 kg, the authors considered this occluder to be suitable for this feline patient with a body weight of 2.22 kg. According to the recommendations provided by the device company, device sizing is based on the diameter of the distal coil, which must not be more than 2 mm larger than the estimated ampulla's diameter. This allows the coils to lodge in the ductal ampulla without interfering with the aortic flow and for this to be filled with as much material as possible. In addition, the proximal coil diameter must not be more than 3–4 mm larger than the estimated pulmonary ostium diameter to guarantee appropriate anchoring. Compared with the traditionally used human medicine device (Nit-Occlud®), it has been suggested by the device company that the Vet-PDA Occluder™ presents higher coil flexibility as well as a specific tip curve that aims to improve the alignment with the device to ease delivery manoeuvres. The degree of stiffness of the device decreases from the aortic side to the pulmonary side, allowing the coil to adapt accordingly to the anatomy of the PDA. This ability of the coils to adapt to the ductal ampulla allows this device to be used in almost all types of PDA cases, apart from type III whose absence of the pulmonary ostium prevents correct stability.

The device is presented premounted into a delivery cable, and all sizes can be delivered using a 4-Fr catheter (55-cm length). The Vet-PDA Occluder™ device is available through the company's website. As described in this case, the first two distal loops of the device are released into the descending aorta, the catheter is pulled back gently into the mid-portion of the PDA ampulla, and more additional loops are released allowing the device to acquire a conical shape into the ampulla that tapers gradually towards the pulmonary side. The release of the device must be performed without making much traction as dislodgement of the device into the pulmonary artery may occur if the tension is excessive. Then, the last proximal loops are positioned in the pulmonary side in a reverse conical direction, increasing the device's diameter and promoting better anchoring. Prior to release, repositioning is also possible with the occluder.

As it can be seen in this patient, it is not rare (unpublished observation reported by the company) for the Vet-PDA Occluder™ not to adopt the native morphology on the pulmonary side. The final conformation of the device in human, canine, and now feline models seems to be dependent on the morphology of the ductal ampulla (for the ampulla body loops) and the shape and size of the ostium (final loops released). The procedure is considered successful if an effective closure of the PDA is achieved by total closure or if there is slight residual flow visualised through the centre of the device. Preliminary studies performed by the device company (unpublished) indicate that the morphology of the implanted device has no direct effect on the

[m] Amplatz® Canine Duct Occluder, Infiniti Medical, LLC Haverford, PA, USA.
[n] Amplatzer® Duct Occluder, AGA Medical Corp., Plymouth, MN, USA.
[o] Amplatzer® Vascular Plug, AGA Medical Corp., Plymouth, MN, USA.
[p] Flipper™ Detachable Embolization Coil, Cook Medical Inc., Bloomington, IN, USA.
[q] Nit-Occlud® coil, PFM Medical AG, Cologne, Germany.
[r] Santana AJ, Saavedra D, Perdigón M, Matos JI, García-Rodríguez SN, Montoya-Alonso JA. Percutaneous closure of patent ductus arteriosus with the Vet-PDA Occluder™ device in dogs. Proceedings ECVIM-CA Congress 2023, Barcelona (Spain).

outcome of the implant as long as the patient meets the criteria described earlier. The same unpublished observations describe the following potential complications during the procedure: air embolism, thromboembolism, arrhythmias, damage to the heart, heart valves, or blood vessels, embolisation of the occluder requiring percutaneous or surgical intervention, endarteritis, heart failure, haemolysis, hypotension or shock, infection, occluder fracture or damage, stenosis of the left pulmonary artery or descending thoracic aorta, or death.

In the case presented, mild residual blood flow three months after the procedure was still seen with echocardiography. This is considered a common finding that can be observed 24 h after PDA occlusion in up to 50%—66% of dogs treated with coil occlusion embolisation. Nevertheless, in most of the cases, a residual flow is not haemodynamically significant [8,9]. Furthermore, late complete closure of the PDA has been reported in up to 29% of dogs and 87% of human patients [8], with mild to moderate immediate persistent postoperative residual blood flow. In human medicine, complete closure rates of up to 100% using the Nit-Occlud® device has been reported at 6-month follow-up[14].

In this cat, the reduction in the left chamber's preload successfully correlated with a reduction in the left ventricular internal dimension at end-diastole and with the left atrial-to-aortic annulus ratio at the three-month follow-up.

As previously reported [8—10,12,13], a limitation of the transvenous procedure is the inability to perform an angiocardiography after surgery to confirm PDA occlusion. Nevertheless, the Vet-PDA Occluder™ device was proven effective for ductal occlusion in this cat. Further prospective studies are needed to evaluate the efficacy of this device as well as the possible associated complications compared with other previously described devices and with surgical ligation.

This case report represents the use of the Vet-PDA Occluder™ device in a feline patient and describes the technique step by step. This device represents a feasible alternative for the occlusion of PDA in cats that avoids conventional surgery by thoracotomy and intrathoracic surgical ligation.

Conflicts of Interest Statement

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

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Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jvc.2024.10.004.

Video Number	Title	Description
Video 1	Transthoracic echocardiography	Visualisation of the PDA and colour Doppler mapping: continuous blood flow from the aorta to the pulmonary artery through the PDA
Video 2	Intraoperative fluoroscopy	Intraoperative fluoroscopic video showing retrograde placement of the Vet-PDA Occluder™ device into the PDA: 1.- Advancement of the angled-tip guidewire across the pulmonic valve and ductal opening into the descending aorta. 2.- Advancement of the 4 Fr catheter over the guidewire into the descending aorta. 3.- Selective angiocardiography of the PDA. 4.- The first two loops are released into the descending aorta. The catheter and the device are pulled back into the ductal ampulla.

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Video Number	Title	Description
Video 3	Transthoracic echocardiography	5.- Release of three further loops acquiring a conical shape. 1-1.5 loops left are left within the catheter. 6.- The device position is maintained, and the catheter is pulled back to release the proximal loops into the pulmonary artery side of the PDA. 7.- Complete release of the device. Minimal residual blood flow through the central part of the Vet-PDA Occluder™ device.

PDA: patent ductus arteriosus.

References

[1] Litster AL, Buchanan JW. Vertebral scale system to measure heart size in radiographs of cats. J Am Vet Med Assoc 2000;216:210—4.

[2] Miller MW, Gordon SG, Saunders AB, Arsenault WG, Meurs M, Lehmkuhl LB, Bonagura JD, Fox PR. Angiographic classification of patent ductus arteriosus morphology in the dog. J Vet Cardiol 2006;8:109—14.

[3] Tidholm A. Retrospective study of congenital heart defects in 151 dogs. J Small Anim Pract 1997;38:94—8.

[4] Schrope DP. Prevalence of congenital heart disease in 76,301 mixed-breed dogs and 57,025 mixed-breed cats. J Vet Cardiol 2015;17:192—202.

[5] 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—9.

[6] Hutton JE, Steffey MA, Runge JJ, McClaran JK, Silverman SJ, Kass PH. Surgical and nonsurgical management of patent ductus arteriosus in cats: 28 cases (1991—2012). J Am Vet Med Assoc 2015;247:278—85.

[7] Kharbush RJTD. Transvenous patent ductus arteriosus occlusion via Canine Duct Occluder in a cat. J Vet Cardiol 2021;33:6—12.

[8] Blossom JE, Bright JM, Griffiths LG. Transvenous occlusion of patent ductus arteriosus in 56 consecutive dogs. J Vet Cardiol 2010;12:75—84.

[9] Morgan KRS, Stauthammer CD, Barncord K, Pinkos A, Fundingsland S, Rishniw M. Transvenous detachable coiling of patent ductus arteriosus in small dogs. J Vet Cardiol 2022;42:65—73.

[10] Cala A, Ferasin L, Ferasin H, Domenech O, Bini M, Valenti V, Venco L. Transvenous closure of patent ductus arteriosus with Nit-Occlud® PDA occlusion system in 13 dogs weighing less than 3 kg. J Vet Cardiol 2024;56:23—34.

[11] Kannan BR, Anil SR, Padhi SS, Kumar RK. Transcatheter management of patent ductus arteriosus in sick ventilated small infants. Indian Heart J 2004;56:232—4.

[12] Schneider M, Hildebrandt N. Transvenous embolization of the patent ductus arteriosus with detachable coils in 2 cats. J Vet Intern Med 2003;17:349—53.

[13] Lynn CR, Samper IS, Walsh M, Babineau S, Brisson JO. Transjugular patent ductus arteriosus occlusion in a cat with a peripheral vascular occlusion device. J Vet Cardiol 2021;38:31—5.

[14] Hiremath G, Aggarwal V, Soule K, Bass JL. Immediate angiographic residual shunt using the Nit-Occlud® device for patent ductus arteriosus closure. Adv Interventional Cardiol 2020;16:460—5.

[15] Häggström J, Andersson AO, Falk T, et al. Effect of body weight on echocardiographic measurements in 19,866 pure-bred cats with or without heart disease. J Vet Intern Med 2016;30:1601—11.