CVJ CLUJ VETERINARY JOURNAL

Case Report

Minimally Invasive Occlusion of Canine Patent Ductus Arteriosus: Technical Aspects and Clinical Outcomes from the first experience in Veterinary Medicine in Romania

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Abstract: Patent ductus arteriosus (PDA) is a frequent congenital cardiovascular anomaly in dogs that can lead to significant hemodynamic consequences if left untreated. This report presents three canine cases of PDA treated by minimally invasive transcatheter closure using a Nit-Occluder® coil or an Amplatzer Vascular Plug II (AVP II) via a transjugular approach. All interventions were uneventful under general anesthesia. Complete PDA closure was achieved in two dogs along with a regression of cardiac remodeling. In one dog, residual shunting persisted following AVP II release, likely due to partial device displacement; however, the patient remained asymptomatic at long-term follow-up. Technical difficulties related to atypical ductal anatomy were encountered in one case but did not impede successful device placement. Rapid post-procedural recovery was observed in all dogs. These results suggest the clinical applicability of transcatheter PDA closure and demonstrate that both AVP II and Nit-Occluder devices represent reliable therapeutic options for canine PDA.

Keywords: patent ductus arteriosus, PDA closure, interventional cardiology, transjugular approach, AVP II, Nit-Occluder

1. Introduction

Patent Ductus Arteriosus (PDA) is one of the most common congenital cardiac malformations in dogs (accounting for approximately 20–26% of all congenital malformations, as reported in the literature) and results from the failure of closure of a normal fetal vascular connection between pulmonary trunk and aorta. Breeds most frequently affected include the Bichon Frise, Chihuahua, German Shepherd, Keeshond, Pomeranian, and Poodle. In addition, females are more commonly affected than males [8,3].

In animals affected by PDA, the ductal wall contains more elastic fibers and a decreased number of smooth muscle fibers, making it similar to the aortic wall. Therefore, normal ductal closure does not occur, and blood keeps flowing from the descending aorta into the pulmonary artery. Because the aortic pressure exceeds the pulmonary arterial pressure throughout the entire cardiac cycle, the shunt remains present during both systole and diastole. This ongoing left-to-right shunt causes the pulmonary circulation, left atrium, and left ventricle to become overloaded. The shunt volume is influenced directly by the diameter of the ductus and by the pressure difference between the systemic and pulmonary circulations. Even though compensatory mechanisms like tachycardia and fluid retention may keep systemic output adequate, the chronic left ventricular volume overload increases the workload on the heart. This can result in worsening of the volume overload, of the mitral annulus dilation, and of the mitral regurgitation. Over time, decreased myocardial

Received: 23.12.2025
Accepted: 26.12.2025
Published: 17.02.2026

DOI:10.52331/v30i39407

contractility altering ventricular compliance and rhythm disturbances cause left-sided congestive heart failure [10,12,4].

Interventional closure of patent ductus arteriosus (PDA) in dogs has become a routine procedure in modern veterinary cardiology. Since the first interventional PDA closure reported in 1994, the technique has progressively evolved, including both arterial and venous vascular access, as well as a variety of occlusion devices adapted to ductal morphology and patient's size [9].

Among the most commonly used devices is the Amplatz Canine Duct Occluder (ACDO), introduced since 2007 and deployed via a transarterial approach, and it remains one of the most frequently utilized devices for canine PDA closure due to its proven efficacy and safety. In more recent years, Amplatzer Vascular Plug II devices have been increasingly used, particularly via a transvenous approach, widely described since 2021. Coil embolization has been reported since 2012 and more recently the Nit-Occluder device was introduced into the veterinary literature in 2024, further broadening available interventional options [7,1,2,6,9,5].

In the context of continued technical and device-related advancements, our group recently reported its experience using a low-profile KA microplug for transarterial PDA closure in a dog. This device is particularly advantageous for small-diameter ductus and in small-sized patients, for whom interventional options may be limited. A key advantage of the microplug is the possibility of using a low-caliber introducer sheath equipped with a hemostatic valve, reducing vascular trauma and the risk of hemorrhagic complications and enhancing procedural safety. To the best of our knowledge, this case represented, at the time of its publication, the first reported use of the low-profile KA microplug device, delivered transarterially, for interventional PDA closure in veterinary medicine, underscoring its potential role as a viable alternative in carefully selected canine patients [11].

2. Cases

2.1 Case description

This case report includes three client owned dogs diagnosed with patent ductus arteriosus (PDA). All patients were female, aged between 1 and 2 years, and belonged to the following breeds: Cavalier King Charles Spaniel (CKCS), Dobermann, and Bichon. Two of the dogs had a previously established diagnosis of PDA and were referred for minimally invasive surgical correction. The third dog was referred for pre-anesthetic cardiologic evaluation after thoracic radiographs revealed cardiomegaly and cardiac biomarkers were found to be increased.

All dogs were asymptomatic on presentation, alert, with cardiac auscultation revealing a grade IV–V/VI continuous murmur on the left side of the thorax at the heart base level, along with bounding femoral pulses, pink mucous membranes and a capillary refill time of less than 2 seconds.

Transthoracic echocardiography confirmed a left-to-right shunting patent ductus arteriosus in all three cases, associated with left ventricular volume overload that was classified as mild in two dogs and moderate in the remaining case.

The interventions were performed between December 2022 and September 2023 at Doctor's Vet Univers Interventional Cardiology Laboratory Bucharest, Romania, the first facility of its kind from our country, founded in 2021. According to the authors experience, these represent the first three minimally invasive interventions for patent ductus arteriosus correction performed in dogs in Romania.

2.2 Procedure description

All patients underwent general anesthesia and were positioned in left lateral recumbency on the surgical table. Subsequently, the right external jugular vein was isolated by cut-down tehnique and placement of an introducer sheath at this level has followed. Two types of devices were used for the closure of the patent ductus arteriosus in these procedures. The first device, the Abbott Amplatzer Vascular Plug II, is a nitinol mesh device with multiple layers. The second device the PFM Medical Nit-Occluder, is a flexible, self-expanding nitinol coil designed to conform to the ductal anatomy. In both cases, vascular access and anesthesia were similar; however, the subsequent procedural steps differed slightly, as detailed below.

Correct catheter positioning was confirmed by angiography or fluoroscopic visualization. The guidewire was subsequently removed, and a selective angiography of the PDA was performed by manual injection of contrast medium through the catheter positioned within the ductal ampulla.

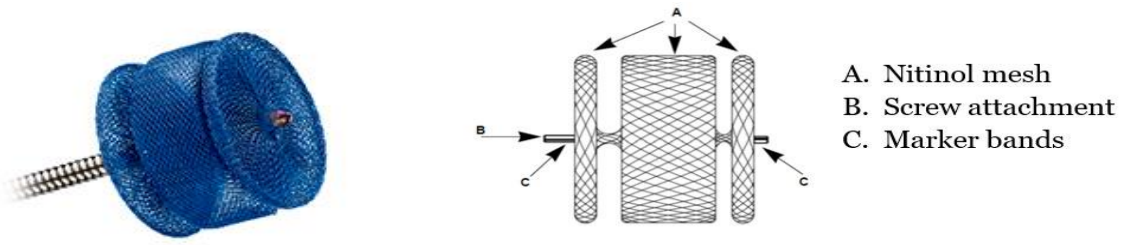


Figure 1. Amplatzer Vascular Plug II device aspect (left) and device diagram (right).
Source: Abbott Laboratories (manufacturer's website).

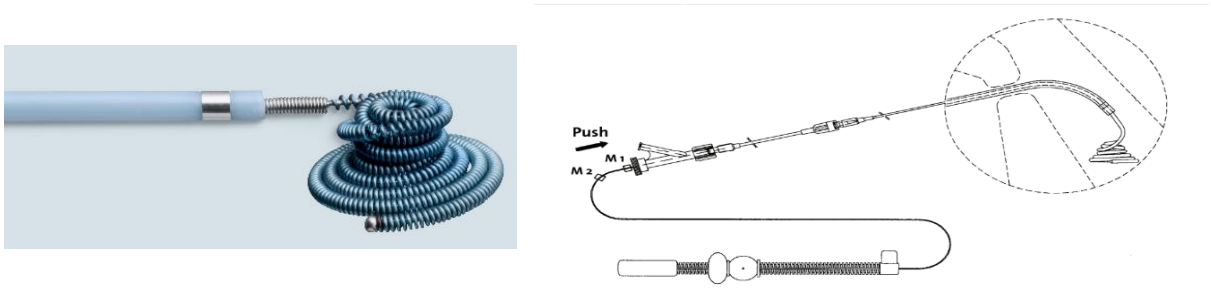
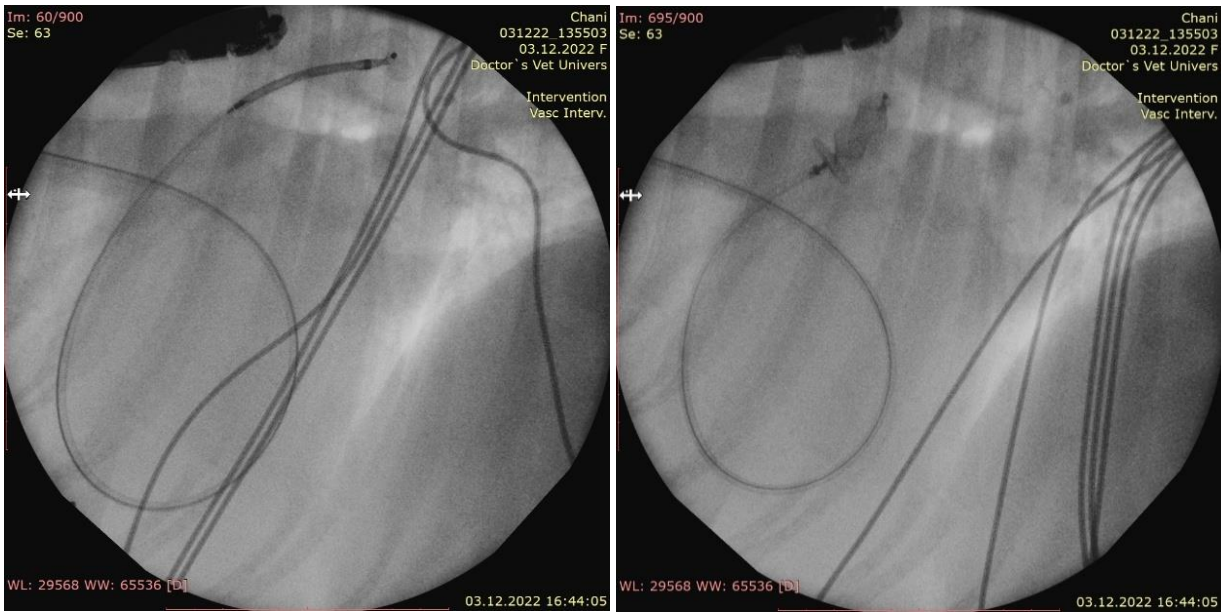


Figure 2. Nit-Occluder device aspect (left) and schematic diagram of the complete delivery system (right).
Source: PFM Medical (manufacturer's website) and product brochure.

Following angiographic assessment, the guidewire was reintroduced to allow exchange of the diagnostic catheter for the guiding sheath. The delivery catheter was advanced into the descending aorta, after which the guidewire was removed. In the next step, the occlusion device was advanced through the guiding sheath and the distal disc was expanded in the descending aorta (Fig. 3a). The guiding sheath and delivery system were gently retracted simultaneously until the distal disc engaged the aortic ostium of the PDA and the withdrawal continued until the expansion of the central portion of the device into the ductal ampulla. Further retraction of the guiding sheath allowed the proximal disc deployment within the main pulmonary artery (Fig. 3b). Intraoperative echocardiography was used to confirm appropriate device positioning and to evaluate residual flow. Following confirmation, the device was detached by counterclockwise rotation of the delivery cable (Fig. 4). All catheters were then removed, and the right jugular vein was closed by suture or ligation.

In contrast to the Amplatzer Vascular Plug II (AVP II) implantation procedure, the Nit-Occlud® device is delivered through a dedicated delivery system supplied as part of the device kit. The equivalent of the delivery sheath is referred to as the implantation catheter, which is advanced over the guidewire in the descending aorta, after removal of the diagnostic catheter and completion of angiography. Following guidewire withdrawal, the device transportation sheath is connected to the implantation catheter (after both of them are flushed with heparinized saline), allowing controlled delivery of the occlusion device. Following placement in the descending aorta, the majority of the device spirals were deployed from the implantation catheter (Fig. 5a) monitoring the fluoroscopic aspect and observing the distal marker position related to the Y-connector. The device and catheter were then retracted together to seat the spirals within the ductal ampulla (Fig. 5b). Finally, the remaining spirals were released into the pulmonary artery, and the device was definitively released once proper position, stability, and ductal occlusion were confirmed (Fig. 6).



(**a**) (**b**)

Figure 3. (**a**) Fluoroscopic image showing the release of the distal disk of the AVP II at the level of the descending aorta; (**b**) Fluoroscopic aspect of the the AVP II device, after the release of the third disk inside the pulmonary artery.

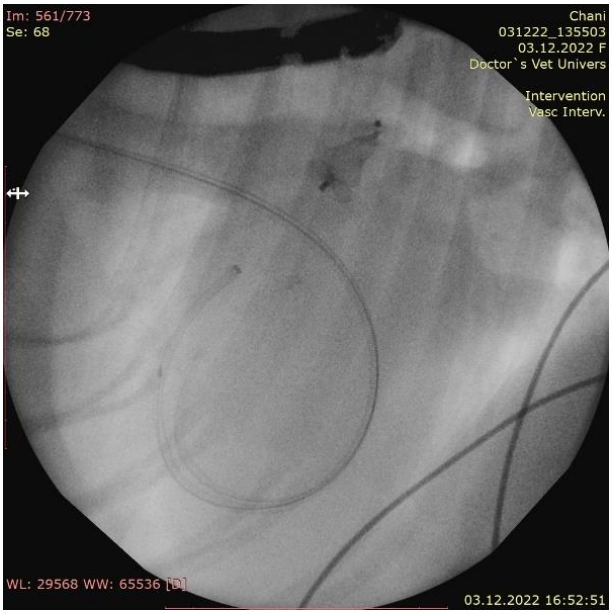
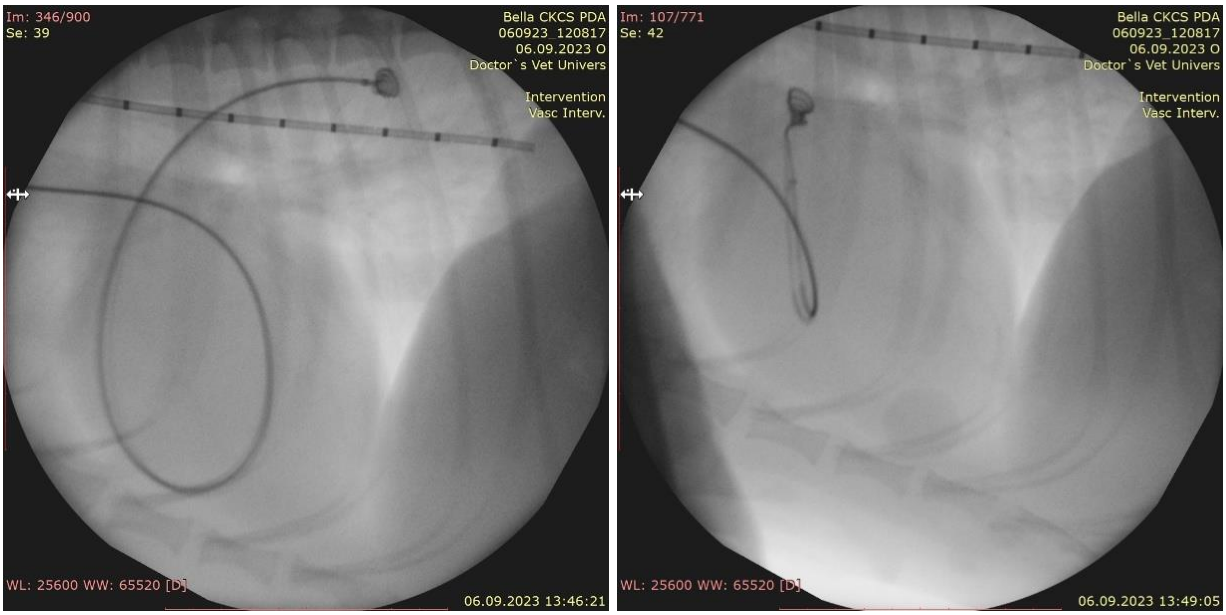


Figure 4. Fluoroscopic aspect after the complete release of the AVP II device.



(**a**) (**b**)

Figure 5: (**a**) Fluoroscopic image with the Nit-occluder loops released in the descending aorta; (**b**) Fluoroscopic aspect showing the Nit-occluder device withdrawn at the level of the ductal ampulla.

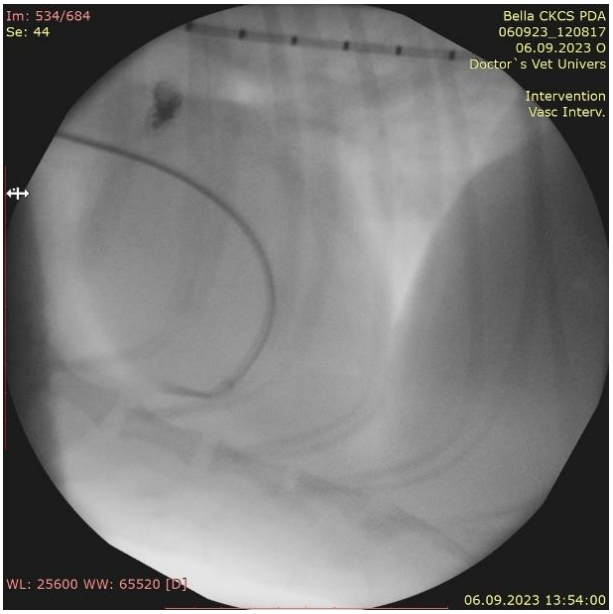


Figure 6. Fluoroscopic aspect after the complete release of the Nit-Occluder device.

3. Results

All three interventions were uneventful under anesthesia. Complete PDA closure was achieved in two dogs, accompanied by subsequent improvement in cardiac morphology. In the third case, although angiography prior to AVP II release indicated complete closure, residual shunting was noted after device deployment, probably due to slight device displacement. At a two-year follow-up, the dog remains asymptomatic, although it continues on positive inotropic medication and exhibits volume overload.

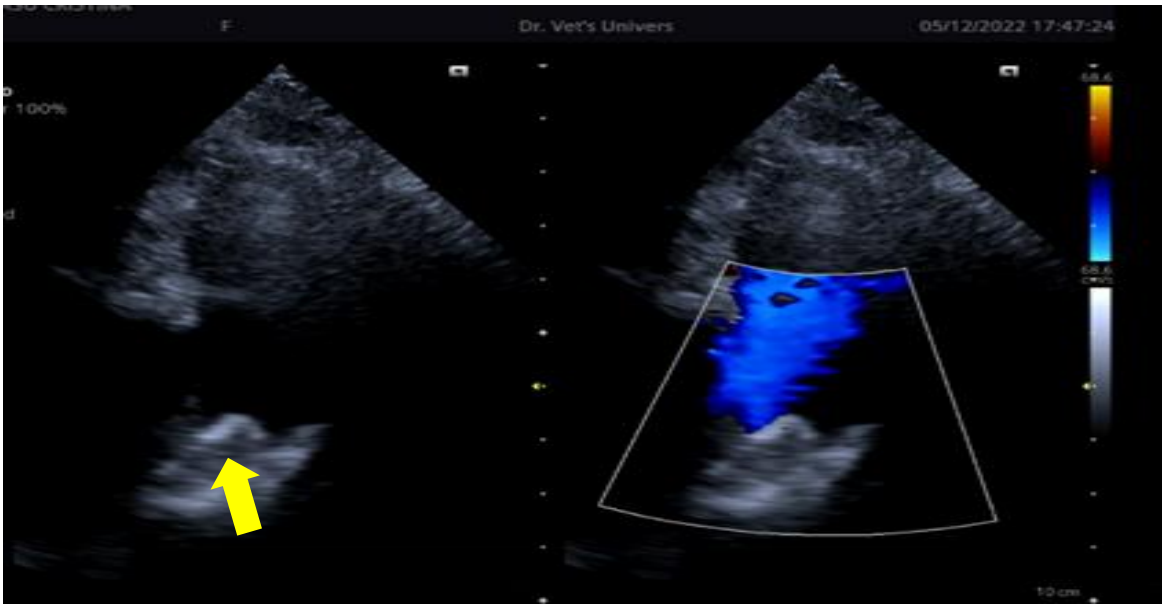


Figure 7. Transthoracic echocardiography performed 48 hours post procedure, CFM at the AVP II device(arrow) showing no residual flow.

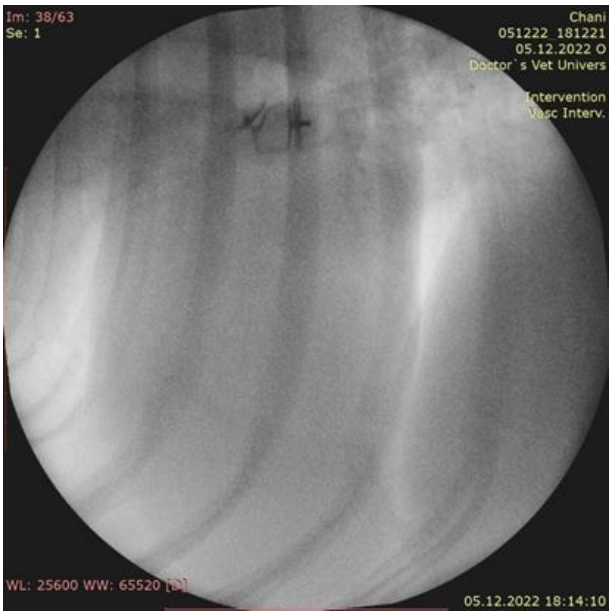
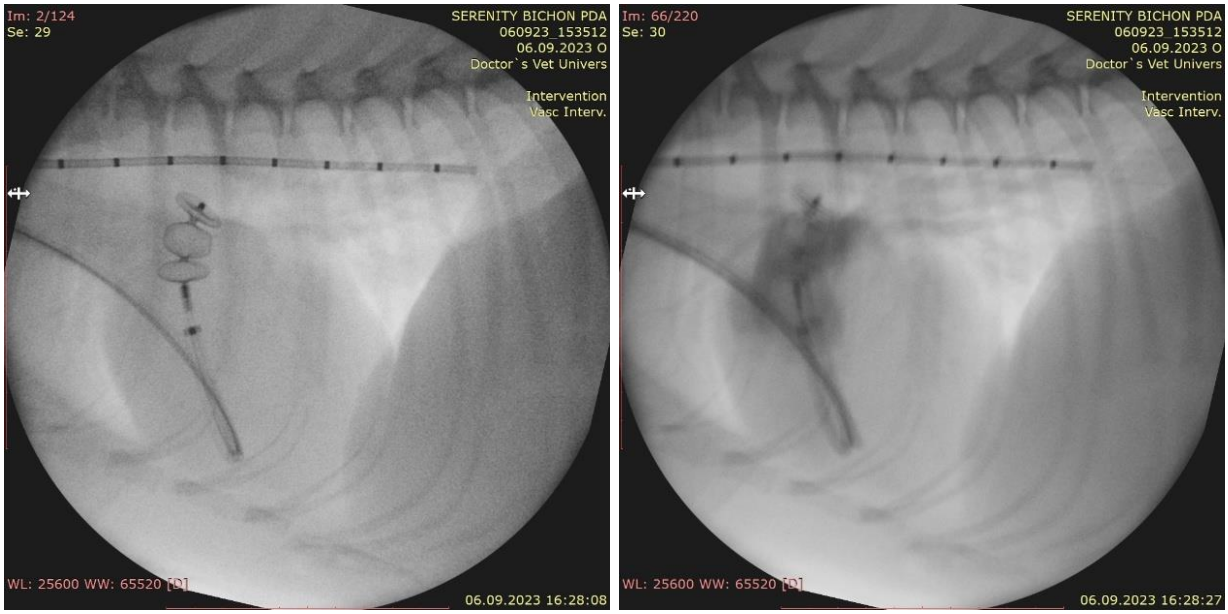


Figure 8. Fluoroscopic aspect of the AVP II device 48 hours post procedure in the Doberman dog.



(**a**) (**b**)

Figure 9. (**a**) Fluoroscopic aspect of the the AVP II device, after the release of the third disk inside the pulmonary artery; (**b**) Pre-release angiography suggesting proper occlusion of the ductus.

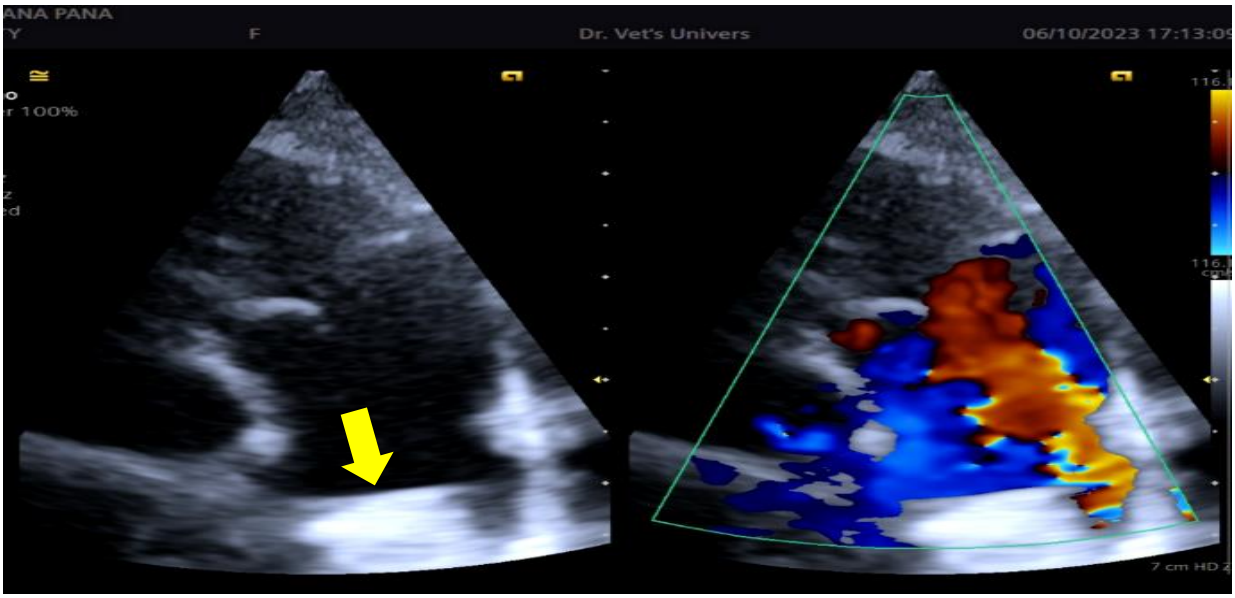


Figure 10. Transthoracic CFM echocardiography performed 1-month post procedure, showing residual flow at the level of the AVP II device (arrow).

4.Discussions

Successful deployment of both the Amplatzer Vascular Plug II and the Nit-Occluder was achieved in all cases and both should be considered viable options for treating this type of congenital cardiovascular anomaly in dogs. The transjugular approach was generally straightforward, although difficulties may arise when crossing the duct from the pulmonary trunk into the aorta, particularly in cases with small ostium or unfavorable ductal angulation. Recovery following the procedure was rapid, and all dogs were discharged just a few hours after regaining consciousness.

In the Bichon dog, pre-release angiography of the AVP II indicated complete occlusion of the ductus arteriosus (Fig. 9b); however, following device release, a residual shunt was identified (Fig. 10), most likely due to partial displacement of the vascular plug. Despite this finding, the patient has remained

asymptomatic to this day (over two-years since the procedure), although positive inotropic therapy has been maintained and persistent volume overload continues to be present.

Regarding the Doberman, catheterization of the ductus with the guidewire proved to be technically challenging, most likely as a result of an atypical PDA anatomy. This assumption was supported by the final orientation of the occlusion device (Fig. 8) in relation to the thoracic cavity, surrounding vascular structures, and adjacent anatomical landmarks. Additionally, the Doberman developed post-procedural cardiac changes resembling dilated cardiomyopathy, characterized by eccentric left ventricular hypertrophy and decreased myocardial contractility. These alterations were attributed to long-standing volume overload caused by the PDA. Ongoing treatment with Pimobendan resulted in a gradual reversal of the observed structural changes.

5. Conclusions

In conclusion, this case report provides additional evidence supporting that transjugular/transvenous PDA closure using AVP II and Nit-Occluder devices is feasible and clinically applicable procedure in veterinary interventional medicine and is an effective therapeutic option in dogs. Despite the small case series, procedural experience suggested that guidewire passage across the ductus arteriosus was technically less challenging in small-sized dogs.

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