

# Transfemoral approach to patent ductus arteriosus occlusion using ACDO in a dog with complex surgical history

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## *Abstract*

A five-year-old spayed female Welsh Corgi weighing 12.4 kg presented with exercise intolerance and was diagnosed with a patent ductus arteriosus (PDA). Due to signs of left-sided volume overload, the dog was initially managed with oral pimobendan and was subsequently referred to the Small Animal Teaching Hospital at Chulalongkorn University for further evaluation and intervention. Upon presentation, the patient was bright, alert, and responsive, with a body condition score of 6 out of 9 and normal muscle condition. The mucous membranes were pink and moist, with a capillary refill time of 1 to 2 seconds. A continuous heart murmur was detected (heart rate: 120 bpm), accompanied by normal lung sounds and mild tachypnea (respiratory rate: 60 bpm) without signs of dyspnea. Femoral pulses were strong with no deficits. Echocardiography confirmed a left-to-right shunting PDA along with mild mitral regurgitation and left-sided volume overload. Thoracic radiographs showed left atrial bulging (VHS 10.3, VLAS 2.5) and a prominent main pulmonary artery. Cardiac-gated computed tomography revealed an anomalous vessel measuring 1.3 cm in length, with a ductal diameter of 1.0 cm at the aortic origin, tapering to 0.4 cm at the pulmonary artery insertion. A prior attempt at surgical ligation was unsuccessful due to dense fibrous adhesions and intraoperative hemorrhage. Consequently, transcatheter occlusion was chosen as the preferred intervention. Under general anesthesia, a transfemoral approach was utilized, employing a 7 Fr introducer sheath inserted into the right femoral artery. Fluoroscopic angiography confirmed the PDA anatomy, and a 7 mm Amplatz Canine Duct Occluder (ACDO) was successfully deployed, resulting in complete occlusion. Post-procedural echocardiography confirmed successful PDA closure and a reduction in cardiac size. No major procedural complications were noted. Minor postoperative events included mild localized swelling at the surgical site on the femoral area and a transient localized allergic skin reaction, both of which resolved without incident. This case underscores the effectiveness and safety of transfemoral ACDO deployment as a minimally invasive option for dogs with PDA, especially when surgical correction is not feasible.

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**Keywords:** Amplatz Canine Duct Occluder, artery, cardiac intervention, patent ductus arteriosus, transcatheter occlusion, Welsh corgi

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## Introduction

Patent ductus arteriosus (PDA) is one of the most common congenital cardiovascular anomalies in dogs. It is characterized by the persistence of a fetal vessel that connects the descending aorta to the main pulmonary artery. This abnormal left-to-right shunting of blood leads to volume overload of the left heart, resulting in progressive dilation of the left atrium and ventricle. If left untreated, this condition can progress to congestive heart failure (CHF) and, ultimately, death (Buchanan, 1992; Kittleson, 1998).

Historically, the standard curative treatment has been surgical ligation via left thoracotomy. Although this approach is effective, it is invasive and carries a notable risk of perioperative morbidity, especially in cases with extensive fibrosis or challenging anatomy (Glaus *et al.*, 2003). In the past two decades, transcatheter occlusion has emerged as a less invasive and increasingly preferred alternative. Various occlusion devices have been successfully employed, including thrombogenic coils (Lloyd *et al.*, 1993), Amplatzer® Vascular Plugs (Belachsen *et al.*, 2022), and the Amplatzer® Canine Duct Occluder (ACDO) (Gordon *et al.*, 2010). Although, these devices have a low risk of migration, anatomical and procedural limitations can hinder the success of either approach. In small dogs, the femoral artery diameter may be too narrow to accommodate the ACDO delivery system, increasing the likelihood of complications such as arterial laceration or catheterization failure (Schneider *et al.*, 2001; Blossom *et al.*, 2010; Singh *et al.*, 2012; Suh *et al.*, 2016). In a retrospective study, the smallest dog to successfully undergo ACDO deployment weighed 2.6 kg, whereas dogs weighing under 2.5 kg were more frequently treated with coils via transvenous (Suh *et al.*, 2016) or transarterial routes (Singh *et al.*, 2012).

Although the Amplatzer® Canine Duct Occluder (ACDO) is one of the most widely used devices for transcatheter closure of canine patent ductus arteriosus worldwide, its clinical use has not been previously reported in Thailand, to the best of our knowledge. Our group had previously described transvenous PDA occlusion using a Cocoon duct occluder in a dog (Buranakarl *et al.*, 2015), which demonstrated the feasibility of transcatheter PDA intervention in Thailand. Unlike our previous report, the present case involved a dedicated ACDO delivered through a transfemoral transarterial approach in a patient with a prior failed thoracotomy. This represents a different occlusion device, delivery technique, and clinical indication. This report details the successful use of ACDO as a minimally invasive rescue strategy following unsuccessful surgical ligation complicated by extensive fibrous adhesions and intraoperative hemorrhage.

## Case Description

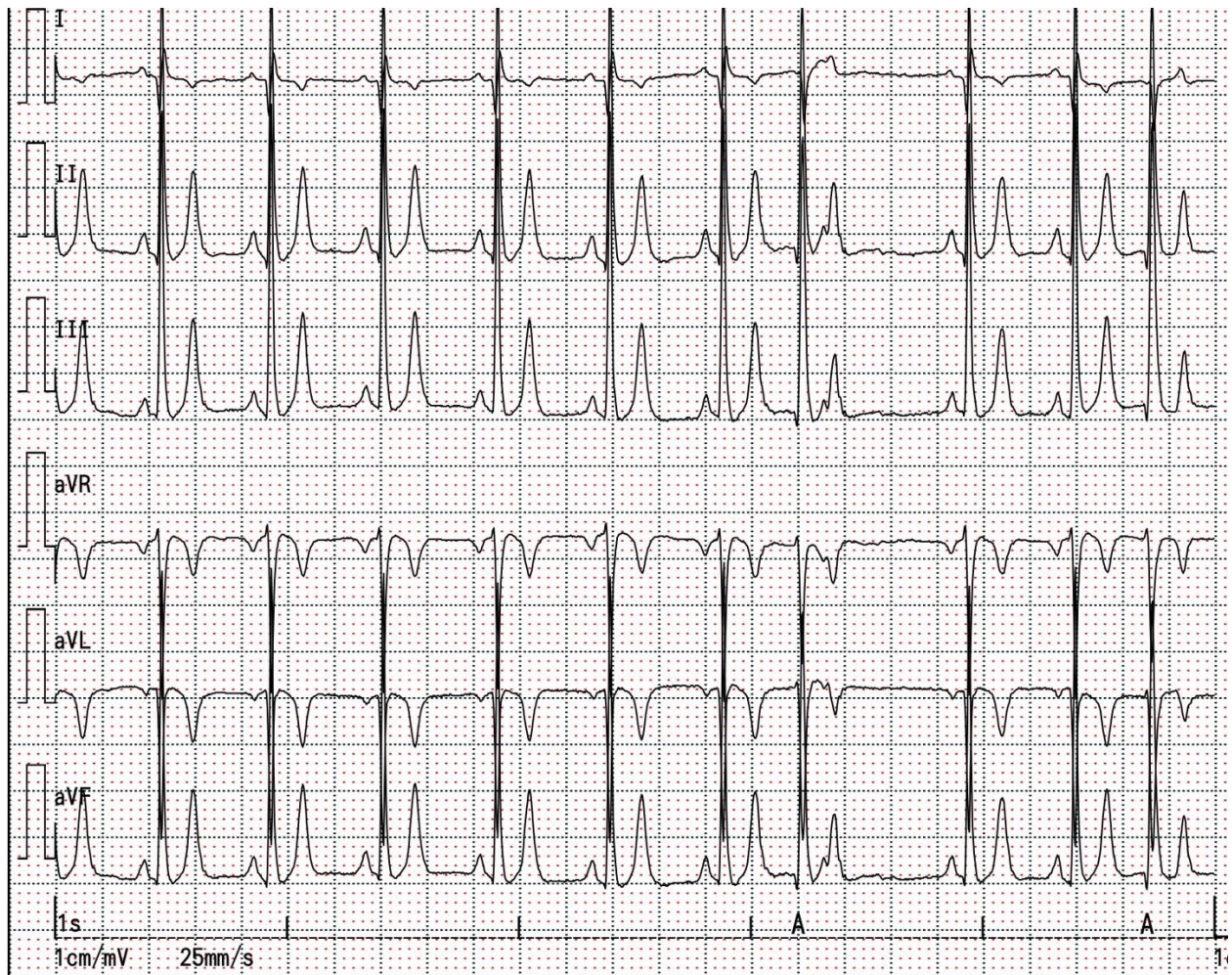
**Case history:** A five-year-old spayed female Welsh Corgi, weighing 12.4 kg, presented with exercise intolerance and was diagnosed with a patent ductus arteriosus (PDA). The dog was initially managed with oral pimobendan at a dosage of 0.3 mg/kg every 12 hours and was subsequently referred to the Small Animal Teaching Hospital at Chulalongkorn

University for further evaluation and correction. Five months ago, a thoracotomy was performed at the small animal hospital to ligate the PDA; however, the procedure could not be completed due to bleeding at the caudal window of the PDA. Upon presentation, the dog was bright, alert, and responsive, with a body condition score of 6 out of 9 and normal muscle condition. The mucous membranes were pink and moist, and the capillary refill time (CRT) was 1-2 seconds. Cardiac auscultation revealed a heart rate of 120 beats per minute and a continuous heart murmur, referred to as a "machinery murmur." The dog exhibited normal lung sounds and mild tachypnea, with a respiratory rate of 60 breaths per minute, but showed no signs of dyspnea. Femoral pulses were strong, with no deficits noted.

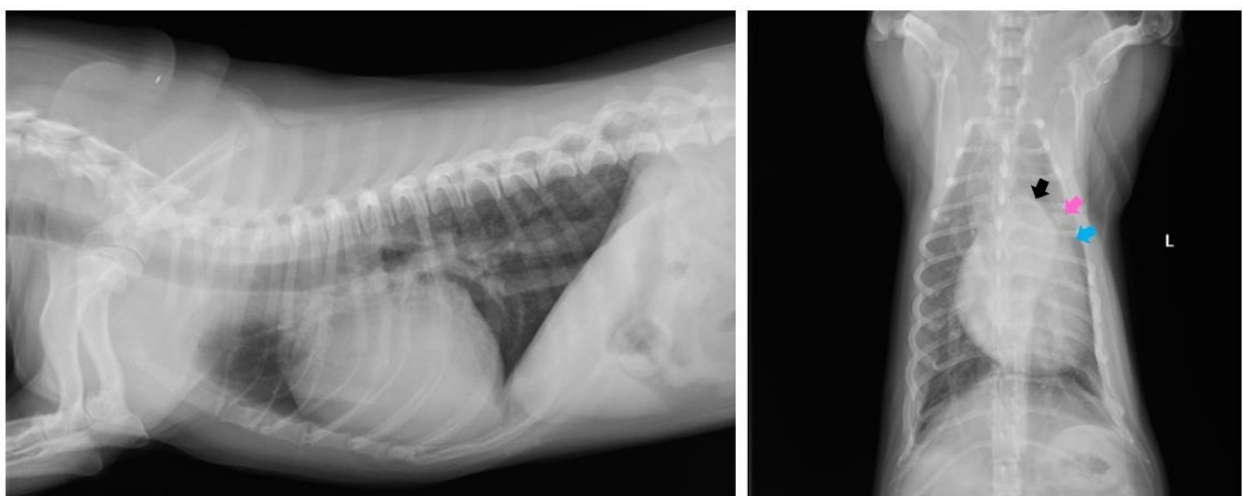
**Assessment:** The clinical assessment of the dogs indicated that the complete blood count (CBC) and blood chemistry profile—comprising alanine transaminase, aspartate transaminase, alkaline phosphatase, blood urea nitrogen, and creatinine—were all within normal limits. An electrocardiogram (ECG) was conducted, revealing a heart rate of 130 bpm and indicating a normal sinus rhythm with supraventricular arrhythmia and a tall R wave, suggestive of left ventricular enlargement (Fig. 1). A thoracic radiograph showed cardiomegaly with left atrial bulging and increased sternal contraction in the lateral projection (VHS = 11.2). In the ventrodorsal position, enlargement of the left auricle, descending thoracic aorta, and main pulmonary artery were noted, known as the "three knuckles sign" (Fig. 2). A definitive diagnosis of patent ductus arteriosus (PDA) was established through echocardiography, using a 1-5 MHz phase array transducer connected to an ultrasound machine (M9, Mindray, Thailand). The echocardiographic examination adhered to standard right and left parasternal imaging planes in line with established veterinary echocardiographic guidelines (Visser *et al.*, 2019). Left ventricular dimensions were obtained from M-mode images at the level of the chordae tendineae, and the left atrial-to-aortic root ratio (LA/Ao) was measured from the right parasternal short-axis view at the heart base. Cardiac chamber dimensions were interpreted based on published canine reference intervals (Cornell *et al.*, 2004). The echocardiogram confirmed the presence of a PDA with a left-to-right shunt, demonstrating left ventricular enlargement consistent with volume overload secondary to the PDA (Fig. 3). The left atrial dimensions remained within published reference intervals, while systolic function was slightly elevated due to volume overload. Additionally, trivial mitral valve regurgitation was observed. Cardiac dimensions and functions were evaluated as detailed in Table 1. Echocardiographic chamber dimensions were assessed according to published canine reference intervals adjusted for body size (Cornell *et al.*, 2004; Boon, 2011; Boswood *et al.*, 2016). Cardiac-gated computed tomography was performed to characterize the ductal morphology and obtain measurements for procedural planning. The duct measured 1.3 cm in length, with an aortic ampulla diameter of 1.0 cm and a minimal ductal diameter (MDD) of 0.4 cm at the pulmonary artery

insertion (Fig. 4). The ACDO size was selected based on the MDD measured by CT, applying an oversizing factor of approximately 1.5–2.0 per the manufacturer's recommendations. This resulted in the selection of a 7-mm ACDO, which features a flat distal disc measuring

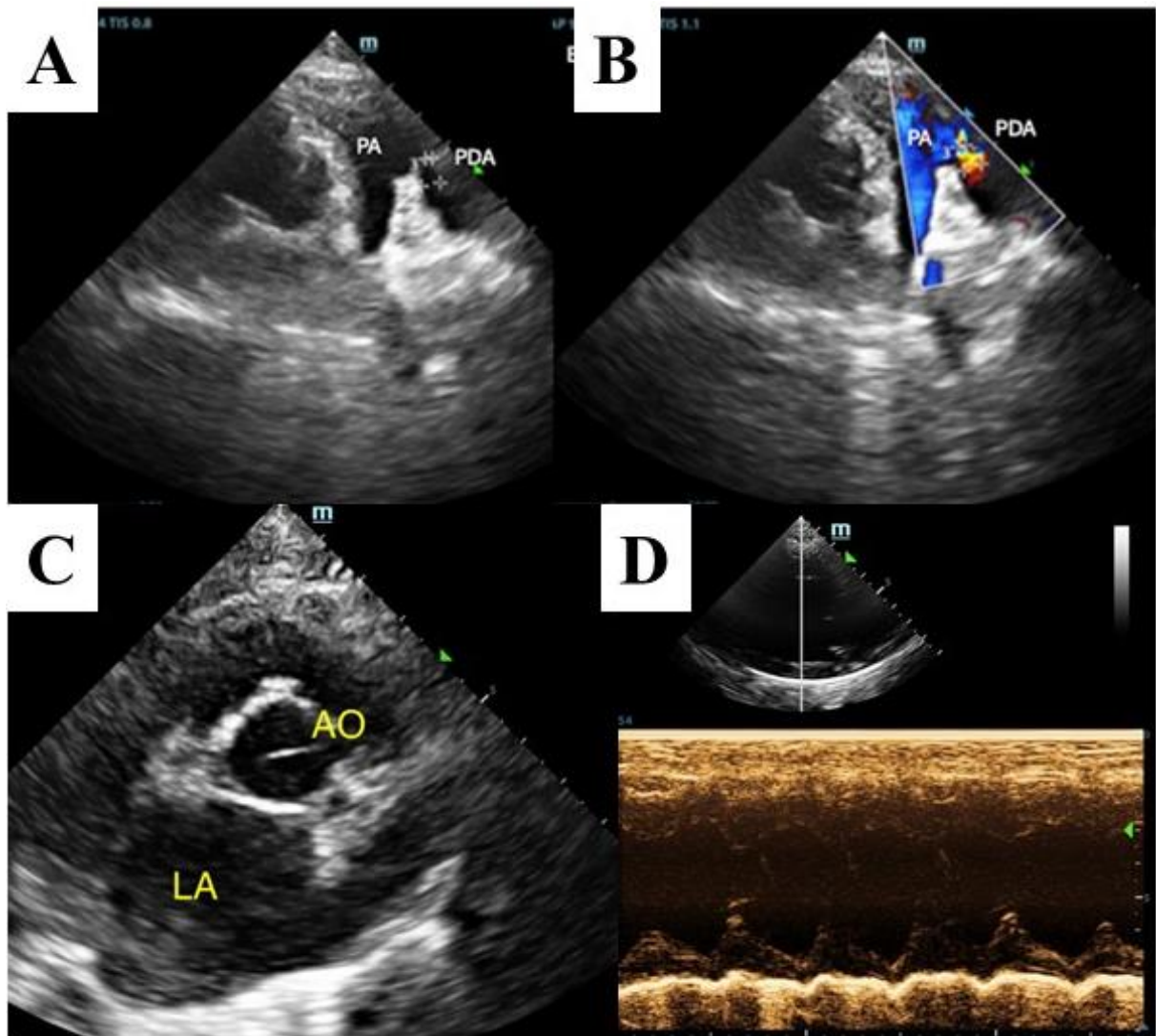
11 mm, a short waist of 7 mm, and a cupped proximal disc measuring 12.5 mm. Blood flow is directed from the aorta to the pulmonary artery. The dog was scheduled for correction of the PDA using a transcatheter ACDO device.



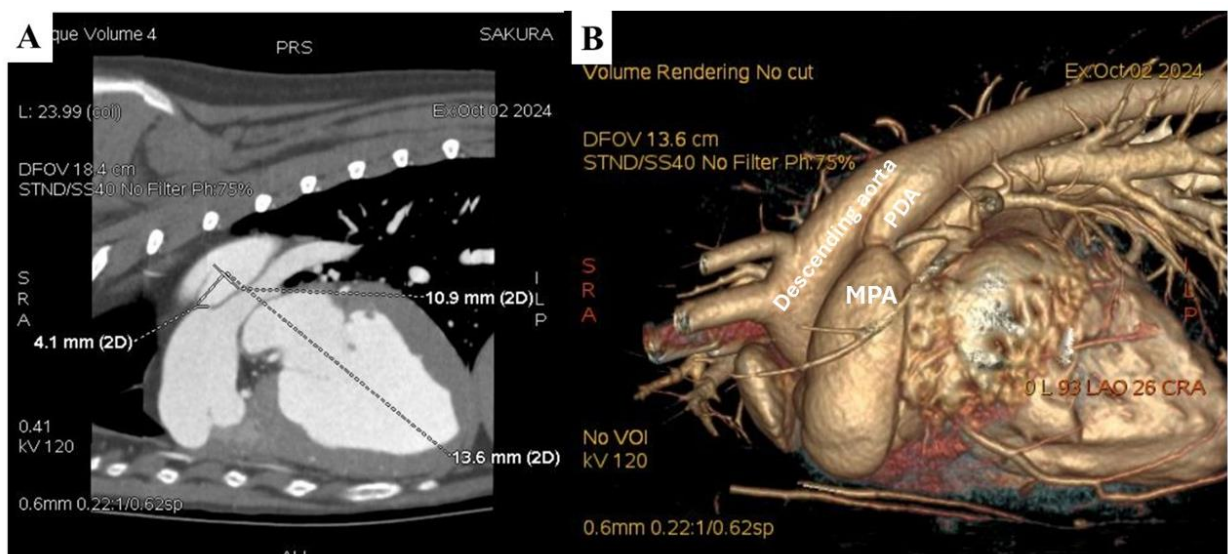
**Figure 1** Representative 6 leads electrocardiogram (ECG) recorded from PDA dog showed high voltage of QRS complexes and supraventricular premature complexes (red arrow).



**Figure 2** Representative thoracic radiograph of right lateral view (left) demonstrating left heart enlargement and ventrodorsal view (right) showing the enlargement of the descending aorta (black arrow), main pulmonary artery (pink arrow), and left auricle (blue arrow).



**Figure 3** Echocardiogram of the dog. It can be noticed that the modified left cranial view shows a patent ductus arteriosus (PDA) and pulmonary artery (PA) on two-dimensional echocardiography (A) and with color Doppler on two-dimensional echocardiography (B). The left atrial to aortic root ratio (LA/Ao; C) obtained from the short-axis view and the left ventricular internal diameter (D) obtained from M-mode. The M-mode echocardiography demonstrated left ventricular enlargement consistent with volume overload, while color Doppler confirmed left-to-right shunting through the PDA.



**Figure 4** Computed tomography (CT) scan of a dog with patent ductus arteriosus (PDA) showed diameter of PDA (type IIA) at the insertion to the main pulmonary artery size 0.4 cm, and the ductal length size 1.3 cm (left), and volume rendering 3D images showed the PDA on the lateral view of the heart (right). MPA = main pulmonary artery.

**Table 1** Echocardiographic variables measured before, 1-day, and 30-day after device implantation.

| parameters        | Before intervention | 1-day after intervention | 30-day after intervention |
|-------------------|---------------------|--------------------------|---------------------------|
| IVSd (cm)         | 1.20                | 1.22                     | 1.10                      |
| LVIDd (cm)        | 3.60                | 2.90                     | 3.00                      |
| LVIDdN            | 1.72                | 1.38                     | 1.43                      |
| IVSs (cm)         | 1.70                | 1.30                     | 1.20                      |
| LVIDs (cm)        | 2.00                | 2.35                     | 2.30                      |
| LVIDsN            | 0.91                | 1.06                     | 1.04                      |
| LVPWd (cm)        | 1.00                | 1.11                     | 1.00                      |
| LVPWs (cm)        | 1.60                | 1.42                     | 1.40                      |
| FS (%)            | 45.0                | 19.15                    | 23.0                      |
| EDV (mL)          | 54.7                | 32.30                    | 35.3                      |
| ESV (mL)          | 12.80               | 19.08                    | 18.2                      |
| SV (mL)           | 41.9                | 13.24                    | 17.0                      |
| EF (%)            | 77.0                | 40.9                     | 48.0                      |
| LA Diam (cm)      | 2.70                | 2.92                     | 2.70                      |
| Ao Root Diam (cm) | 2.10                | 2.18                     | 2.00                      |
| LA / Ao           | 1.25                | 1.34                     | 1.35                      |

Values are presented as an average of 3 cardiac cycles. Ao = aorta; cm = centimeter; Diam = diameter; EF = ejection fraction; EDV = end-diastolic volume; ESV = end-systolic volume; FS = fractional shortening; IVSd = interventricular septum diastole; IVSs = interventricular septum systole; LA = left atrium; LVIDd = left ventricular internal diameter diastole; LVIDdN = normalized left ventricular internal dimensions in diastole; LVIDs = left ventricular internal diameter systole; LVIDsN = normalized left ventricular internal dimensions in systole; SV = stroke volume. LVPWd = left ventricular posterior wall diastole; LVPWs = left ventricular posterior wall systole; mL = milliliters.

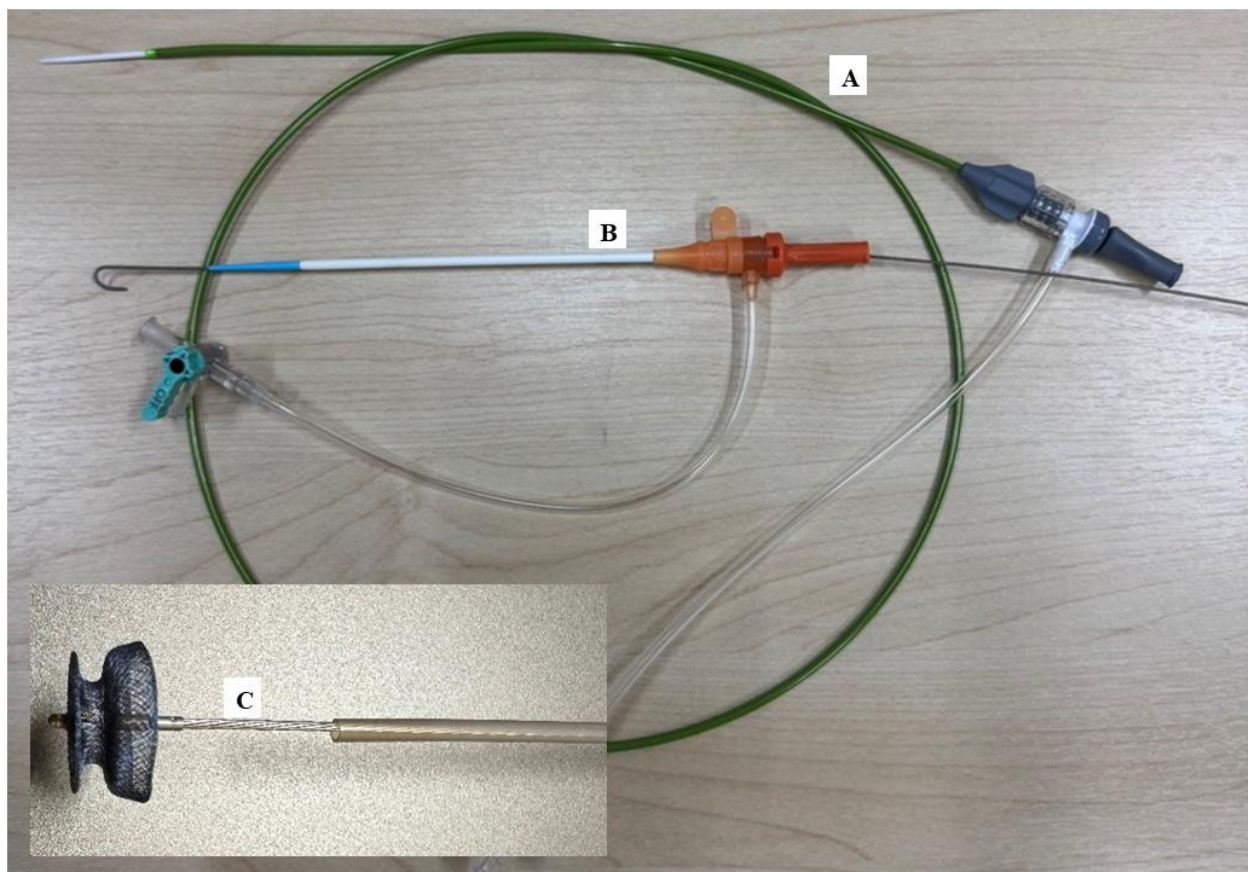
**Transfemoral approach to patent ductus arteriosus occlusion using ACDO:** The transfemoral intervention was performed on this dog using an ACDO (Infiniti Medical, Redwood City, CA, USA; Fig. 5). The anesthetic protocol was adapted from previously published interventional cardiology procedures (Buranakarl *et al.*, 2015; Buranakarl *et al.*, 2017; Kijawornrat *et al.*, 2024) and was conducted in accordance with established principles of veterinary anesthesia and perioperative monitoring (Bailey *et al.*, 2025). In brief, cefazolin (25 mg/kg, IV) and chlorpheniramine maleate (0.4 mg/kg, IM) were used as preoperative medications, while midazolam (0.1 mg/kg, IV), fentanyl (5 µg/kg, IV), and morphine (0.3 mg/kg, IM) constituted the premedication. Anesthetic induction was achieved with etomidate (2 mg/kg, IV), followed by orotracheal intubation and connection to a ventilator. The animal was mechanically ventilated with 100% oxygen using a pressure-controlled ventilator set at a rate of 8-12 breaths per minute, with a tidal volume of 10-15 mL/kg. This procedure maintained an arterial partial pressure of carbon dioxide between 35 and 45 mmHg and an arterial partial pressure of oxygen above 95 mmHg. Body temperature was regulated within a range of 36.5-37°C using a forced-air warming system. A surgical plane of anesthesia was achieved through inhalation of isoflurane, with the end-tidal concentration held between 1 and 1.5%. Acetate Ringer's solution was administered at a rate of 3-5 mL/kg/hr. A loading dose of lidocaine (1 mg/kg IV) was given, and a constant rate infusion (CRI) of fentanyl at a dose of 2.5-5 mcg/kg/hr, along with lidocaine at a dose of 0.75-1.5 mg/kg/hr, was administered via the cephalic vein to ensure an adequate anesthetic plane and analgesia. Prophylactic antibiotics with cefazolin were repeated every 60 minutes throughout the procedure. The dog was positioned in right lateral recumbency with the right leg extended and secured, while the left leg was abducted and secured. Standard limb lead electrocardiograms were utilized to monitor heart rate and rhythm. Doppler flow detection was employed to

monitor systolic blood pressure every 3 minutes. After sterile preparation, a vascular cutdown was performed at the right femoral artery. The Seldinger technique was used to place a 7 Fr introducer sheath into the femoral artery. Heparin (100 IU/kg) was administered to prevent blood clot formation. A multipurpose angiographic catheter (5 Fr), along with a hydrophilic guidewire, was advanced across the ductus, and angiography was conducted to confirm the PDA anatomy, catheter position, and fluoroscopic orientation prior to device deployment (1 mL/kg of iobitridol, Xenetix®; Guerbet, Paris, France). The ACDO had already been selected based on preoperative CT measurements, so angiography was employed for procedural guidance rather than for quantitative ductal sizing. After the PDA was located, the MPA catheter was replaced by the ACDO delivery sheath (7 Fr.). After the tip of the delivery sheath was inside the main pulmonary artery, the ACDO was inserted into the delivery sheath and advanced to deploy the distal disc within the main pulmonary artery (Fig. 6A). The distal disc was pulled back until it was against the vessel wall. Then withdraw the delivery sheath while maintaining the ACDO position. Next, advance the ACDO delivery cable to allow the proximal disc to set (Fig. 6B). Perform a tug test to ensure the device is positioned and the distal disc is engaged. Following deployment of the ACDO and completion of the tug test, repeat angiography was performed by injecting contrast medium through the angiographic catheter positioned in the descending aorta. The absence of contrast passage through the ductus confirmed satisfactory device positioning and complete occlusion without angiographically detectable residual shunting (Fig. 6C). After confirmation of complete occlusion, the ACDO was released by anticlockwise rotation of the delivery cable (Fig. 6D). After that, the femoral artery was sutured with a simple continuous pattern (6-0 Monoplius) followed by standard tissue closure. The dog was admitted for 2 days at the hospital, and post-operative medications included an antibiotic (cephalexin 25

mg/kg, q12h, PO) and an antihistamine (chlorpheniramine 0.5 mg/kg, q12h, PO). No major perioperative or device-related complications were observed. Two minor postoperative events occurred: mild localized swelling at the femoral surgical site following vascular cutdown, which resolved with routine postoperative care, and a mild localized allergic skin reaction, which was successfully treated with oral chlorpheniramine without recurrence.

**At follow up:** Echocardiography, thoracic radiograph, electrocardiography, and blood pressure were performed at the 1-day and 30-day follow-ups (Table 1). Postoperative echocardiography demonstrated a reduction in left ventricular internal diameter and end-diastolic volume, with no residual ductal flow observed. However, left ventricular systolic function was decreased, and a bulging ascending aorta was observed. Immediate post-deployment angiography demonstrated complete occlusion of the ductus with no passage of contrast through the PDA before device

release (Fig. 6C). At both the 1-day and 30-day follow-up examinations, color Doppler echocardiography demonstrated no detectable residual ductal flow. The thoracic radiograph indicated cardiomegaly associated with mild pulmonary artery enlargement. Additionally, the metallic ductal occluder was confirmed to be in situ. There was underinflation of the ventral portion of the lung. The electrocardiogram displayed a normal sinus rhythm with a heart rate of 100 beats per minute, accompanied by supraventricular arrhythmia characterized by a tall R wave. The systolic blood pressure recorded was 139 mm Hg. The echocardiography conducted 30 days post-device occluder placement revealed normal sizes of the left atrium and left ventricle, along with trivial mitral valve regurgitation. Although the left ventricular systolic function remained decreased, the bulging ascending aorta was no longer observed. There was still no residual flow at the PDA. The systolic blood pressure recorded was 106 mm Hg.

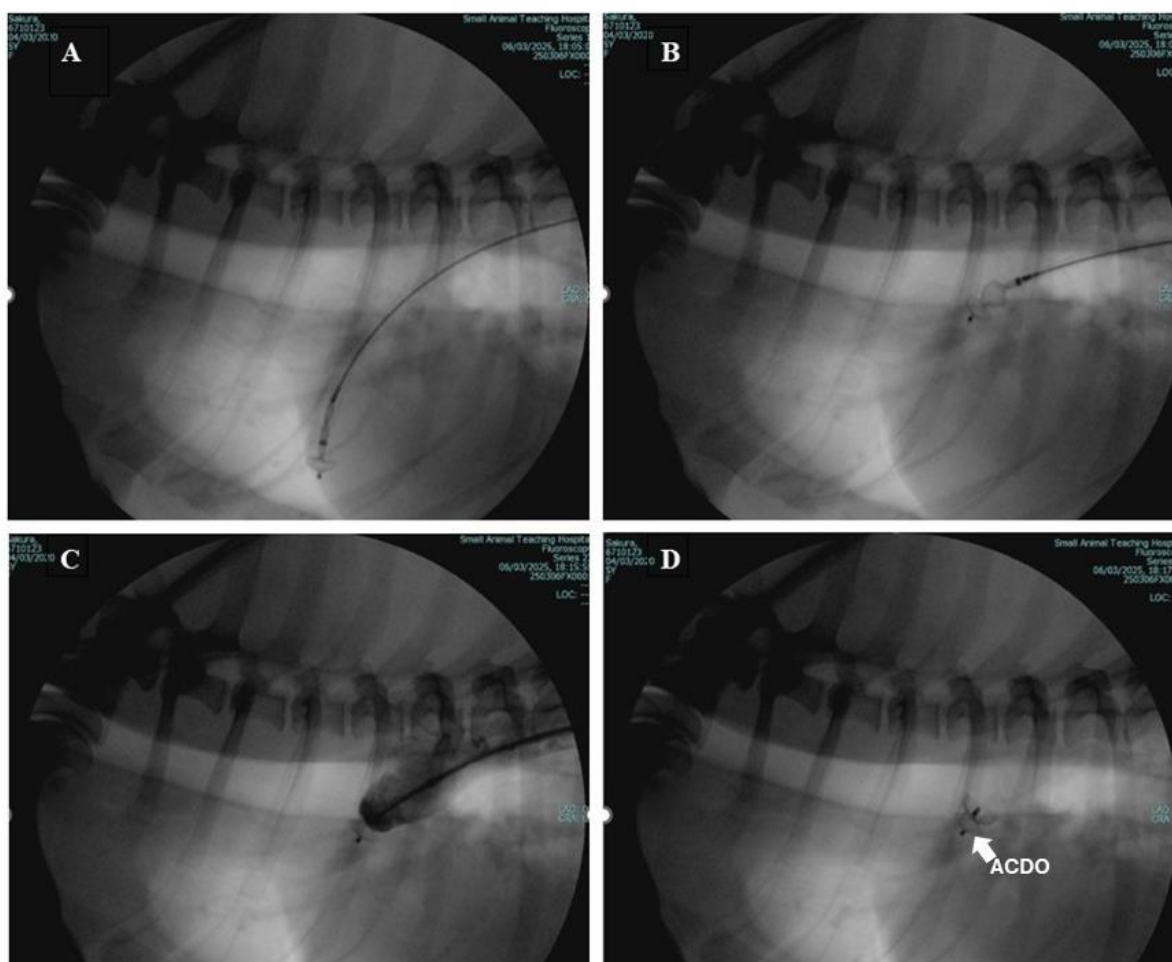


**Figure 5** Representative commercially available 6 Fr delivery sheath (A), 7 Fr guiding catheter (B), and Amplatz® Canine Duct Occluder®.

### Discussion

Patent ductus arteriosus is still one of the most common congenital heart defects in dogs. If it is not treated, it can have serious clinical and hemodynamic effects (Buchanan, 1992; Schneider *et al.*, 2001). Surgical ligation has long been the best way to treat this disease,

but it is not without its problems, especially in dogs with fibrotic adhesions, a history of surgery, or unusual ductal anatomy (Glaus *et al.*, 2003). For these kinds of problems, minimally invasive options like transcatheter occlusion with the ACDO are a safe and effective way to treat them (Gordon *et al.*, 2010).



**Figure 6** Representative fluoroscopic images. Panel A: The distal disc is exteriorized into the main pulmonary artery. Panel B: The proximal disc is exteriorized while retracting the catheter over the cable. Panel C: Repeat angiography performed before device release by hand injection of 1 mL/kg of contrast through the 5 Fr delivery catheter positioned within the descending aorta, demonstrating complete cessation of contrast flow through the ductus, confirming satisfactory device positioning and complete occlusion prior to release of the ACDO. Panel D: The device has been released at the location of the PDA.

To the best of our knowledge, this study is the first published report describing transarterial PDA occlusion using an Amplatz® Canine Duct Occluder (ACDO) in Thailand. Nevertheless, we believe the primary clinical contribution of this report is not merely its geographic novelty but the successful application of ACDO as a rescue intervention following unsuccessful surgical ligation complicated by extensive fibrous adhesions and intraoperative hemorrhage. This case demonstrates that transcatheter intervention can provide an effective alternative when repeat surgical correction is considered technically challenging or associated with increased operative risk. A detailed cardiac-gated computed tomography and echocardiographic evaluation were performed before intervention. Both imaging modalities demonstrated that the ductal morphology and dimensions were suitable for ACDO placement. In this case, cardiac-gated CT served as the primary imaging modality for procedural planning and device selection because it provided detailed three-dimensional anatomical information, including the minimal ductal diameter and ductal morphology. Consequently, intraoperative angiography was used primarily to confirm catheter position, PDA anatomy, and device deployment rather than for quantitative ductal sizing.

This strategy may be particularly valuable in dogs with previous surgical intervention or distorted peri-ductal anatomy, where detailed three-dimensional visualization facilitates procedural planning and device selection before catheterization.

The femoral artery approach worked on this 12.4 kg Welsh Corgi, which is in line with what other studies have found: ACDO delivery systems can be safely used on small dogs (>2.6 kg) (Singh *et al.*, 2012; Suh *et al.*, 2016). It can be difficult to access the femoral artery in toy breeds because their vessels are small and their delivery sheaths are stiff (Schneider *et al.*, 2001; Blossom *et al.*, 2010). However, accessing the femoral artery in toy breeds can be challenging due to their small vessels and stiff delivery sheaths (Schneider *et al.*, 2001; Blossom *et al.*, 2010); this case demonstrates that the procedure is still a viable option for dogs that weigh more than the lower weight limit.

Immediate angiographic confirmation of complete ductal occlusion was followed by serial echocardiographic examinations demonstrating no detectable residual ductal flow, supporting successful device implantation despite the absence of publication-quality postoperative Doppler images.

Two minor postoperative events were observed: mild swelling at the femoral surgical site associated

with vascular access and a transient localized allergic skin reaction. Both resolved with conservative management and did not affect the patient's recovery or the procedural outcome. No vascular, neurological, or device-related complications were encountered. In the present case, FS and EF decreased after PDA occlusion, with EF declining from 77.0% before intervention to 40.9% at 1 day and partially recovering to 48.0% at 30 days. This finding should not necessarily be interpreted as primary myocardial failure. Before PDA closure, the left ventricle ejects into both the systemic circulation and the low-resistance ductal runoff to the pulmonary artery. After occlusion, the low-resistance shunt is removed, which causes a sudden drop in preload and a rise in effective left ventricular afterload because all LV output has to go through the systemic circulation. Consequently, load-dependent indices such as FS and EF may decrease transiently after PDA closure. Similar reductions in systolic indices have been described after interventional PDA closure in dogs and humans (Van Israel *et al.*, 2003; Kim *et al.*, 2008; Stauthammer *et al.*, 2013; Sabri *et al.*, 2025). These kinds of functional decreases are usually temporary and have minor consequences.

This case shows that catheter-based PDA occlusion can be used on patients who have had surgery failure before, using ACDO. This procedure is different from previous reports from Thailand, like the use of a cocoon duct occluder in a large-breed dog (Buranakarl *et al.*, 2015). The controlled use of the occluder, real-time fluoroscopic guidance, and angiographic confirmation all helped lower the risks of the procedure. These parts are similar to methods found in the international literature and support the idea that this method can be used in different clinical settings (Gordon and Miller, 2005).

This report is limited by the relatively short follow-up period and the absence of publication-quality postoperative color Doppler images demonstrating the absence of residual ductal flow. Nevertheless, immediate angiographic confirmation of complete occlusion and serial echocardiographic examinations showing no detectable residual shunting support the short-term success of the procedure. Longer-term follow-up would be valuable to further confirm sustained device stability and complete ductal closure.

In conclusion, this case demonstrates that transarterial ACDO deployment can serve as a feasible and effective rescue strategy for dogs with PDA in which conventional surgical ligation is unsuccessful or technically challenging. Although this case represents, to the best of our knowledge, the first reported clinical use of an ACDO in Thailand, the broader clinical significance lies in illustrating the value of minimally invasive transcatheter interventions for managing complex PDA cases.

### Acknowledgments

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**Ethics statement:** The owner provided informed consent for the diagnostic procedures, treatment, and publication of this case report and accompanying images. This report describes the clinical management of a privately owned dog undergoing a therapeutic procedure performed as part of routine veterinary care. Because the research did not involve experimental procedures or interventions, institutional animal ethics approval was unnecessary.

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**Declaration of competing interests:** The authors disclose no known competing or financial interests or personal relationships that could affect the present study.

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