DOI: 10.1002/vms3.634

CASE REPORT

WILEY

Late recanalization after complete occlusion of patent ductus arteriosus in a Pembroke Welsh Corgi with von Willebrand disease

Masaki Kochi[1,#] | Keisuke Sugimoto[2,#] | Michito Inoue[1] | Takuma Aoki[3]

[1] Division of Cardiology, Matsubara Animal Hospital, Matsubara, Japan

[2] Department of Internal Medicine 2, Faculty of Veterinary Medicine, Okayama University of Science, Imabari, Japan

[3] Department of Small Animal Surgery, Faculty of Veterinary Medicine, Azabu University, Sagamihara, Japan

Correspondence
Keisuke Sugimoto, Faculty of Veterinary Medicine, Okayama University of Science, Imabari-shi, Ehime 794–8555, Japan.
Email: k-sugimoto@vet.ous.ac.jp

[#]These authors equally contributed to this study.

Abstract

A 36-month-old female Pembroke Welsh Corgi with a cardiac murmur weighing 12.6 kg was referred to the Matsubara Animal Hospital cardiology service. Echocardiography revealed a patent ductus arteriosus. The dog underwent ductus arteriosus closure using an Amplatz Canine Duct Occluder. After the operation, we suspected coagulation and a platelet disorder because of the slightly increased haemorrhage during the operation, postoperative purpura around the surgical wound inside of the thigh, and dog breed, which is known to be commonly affected with von Willebrand disease (vWD). Subsequently, type 1 vWD was confirmed. Complete occlusion was achieved 1 month after the operation; however, 2 months after the operation, recanalization appeared. Recanalization progressed gradually; cardiac redilation was not detected 6 years after the operation. The late recanalization was most likely associated with vWD. In canine breeds pre-disposed to developing vWD, pre-operative testing may be indicated prior to patent ductus arteriosus occlusion, though the prevalence of vWD is rare.

KEYWORDS
Amplatz Canine Duct Occluder, canine, dog, echocardiography, patent ductus arteriosus, von Willebrand disease

1 | CASE DESCRIPTION

A 36-month-old female Pembroke Welsh Corgi with a cardiac murmur weighing 12.6 kg was referred to the Matsubara Animal Hospital cardiology service. The dog had a continuous grade V/VI murmur, heart rate of 112 beats per minute, and bounding pulses of the femoral artery. Blood examination, including complete blood count, serum chemistry, prothrombin time, and activated partial thromboplastin time, were within reference ranges. Thoracic radiography revealed cardiomegaly; the vertebral heart score was 11.0 vertebrae (reference interval: 8.5–10.6 vertebrae) (Buchanan & Bucheler, 1995), and the pulmonary vessels were enlarged (Figure 1a,b). Echocardiographic examination revealed that left ventricular was enlarged but left atrial was normal (normalized diastolic left ventricular internal diameter of 2.03 and left atrial-to-aortic ratio of 1.25). There was continuous flow in the main pulmonary artery originating from a concurrent left-to-right shunting through a patent ductus arteriosus (PDA) (Figure 1,d). We diagnosed isolated PDA based on the mentioned findings.

One month later, a transarterial embolization of the PDA was performed by implanting an Amplatz Canine Duct Occluder (ACDO) under general anaesthesia according to a previously described protocol (Nguyenba & Tobias, 2007). A surgical cutdown was used to access

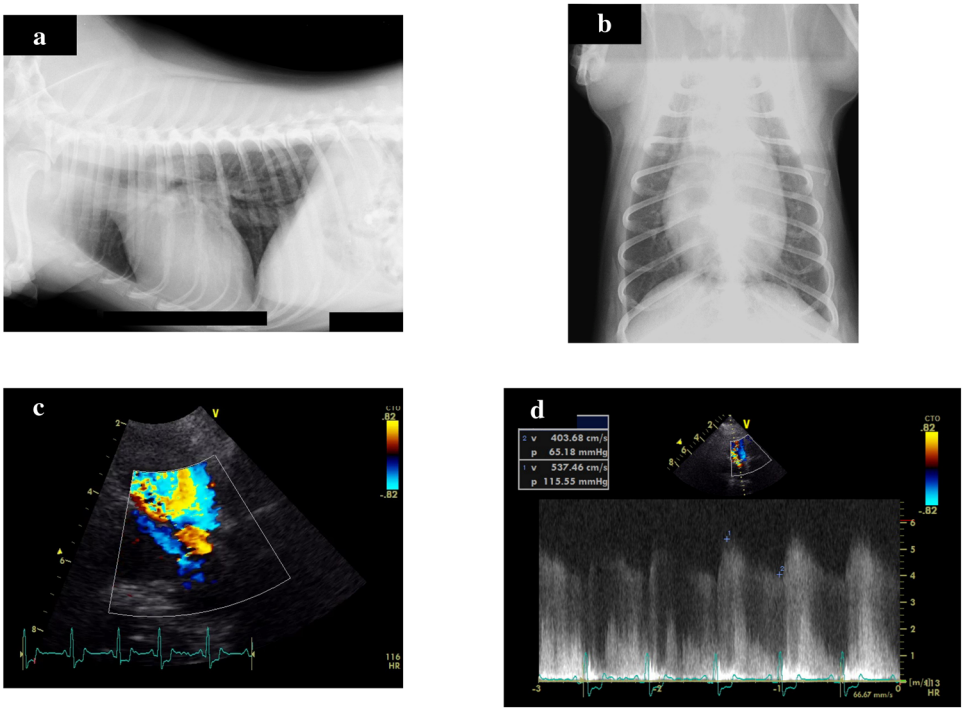

FIGURE 1 Thoracic radiography and right parasternal long axis transthoracic echocardiographic images on the first examination. (a and b) Thoracic radiography revealed cardiomegaly with enlarged pulmonary vessels. Continuous colour (c) and spectral (d) Doppler flow

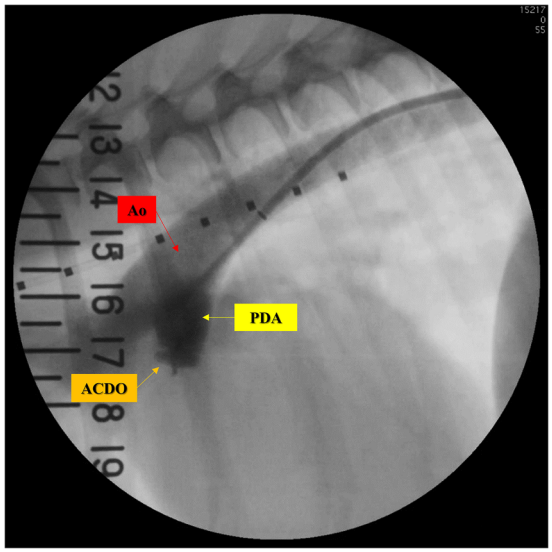

FIGURE 2 Intraoperative angiography after implanting an Amplatz Canine Duct Occluder. A complete occlusion of the ductus arteriosus was immediately reached. ACDO, Amplatz Canine Duct Occluder; Ao, aorta; DA, ductus arteriosus

the right femoral artery. Although the haemorrhage slightly increased, the catheter was inserted without complications. On the angiography images, the pulmonary ostium of the PDA measured 3.75 mm and the ductal ampulla was 9.45 mm. An ACDO with a waist diameter of 6 mm was implanted according to the manufacturer's recommendations. Immediate complete occlusion of the PDA was achieved by intraoperative angiography (Figure 2).

After the operation, we suspected a coagulation and/or platelet disorder because of the slightly increased haemorrhage during the operation and post-operative purpura around the surgical wound inside of the thigh. Additionally, the dog belonged to a breed that is predisposed to von Willebrand disease (vWD). Subsequently, type 1 vWD was confirmed by genetic testing (Kahotechno, Co., Ltd, 680-41, Iizuka, Fukuoka, 820-0067, Japan).

Complete occlusion was confirmed 3 days after the operation by transthoracic colour Doppler ultrasonography (Figure 3a), as well as 1 month after the operation, when the cardiac dilation was also improved. However, 2 months postoperatively, recanalization appeared and mild residual flow was observed (Figure 3b); no cardiac murmur or other clinical signs were detected. The flow passed through the ACDO. Although the degree of residual flow was mild, recanalization progressed gradually; cardiac redilation was not detected 6 years after the operation (Figure 3c).

2 | DISCUSSION

Patent ductus arteriosus, a common congenital heart disease in dogs (Schrope, 2015), represents the persistence of the arterial canal that carries blood from the pulmonary artery to the aorta during fetal life and that normally closes within hours after birth in response to hemodynamic and neurohormonal processes (Clyman, 2006). Patent ductus arteriosus is caused by the failure of the closure of ductus arteriosus (DA). The shunting through the DA causes volume overload of the left side of the heart. In untreated dogs, persistence of this

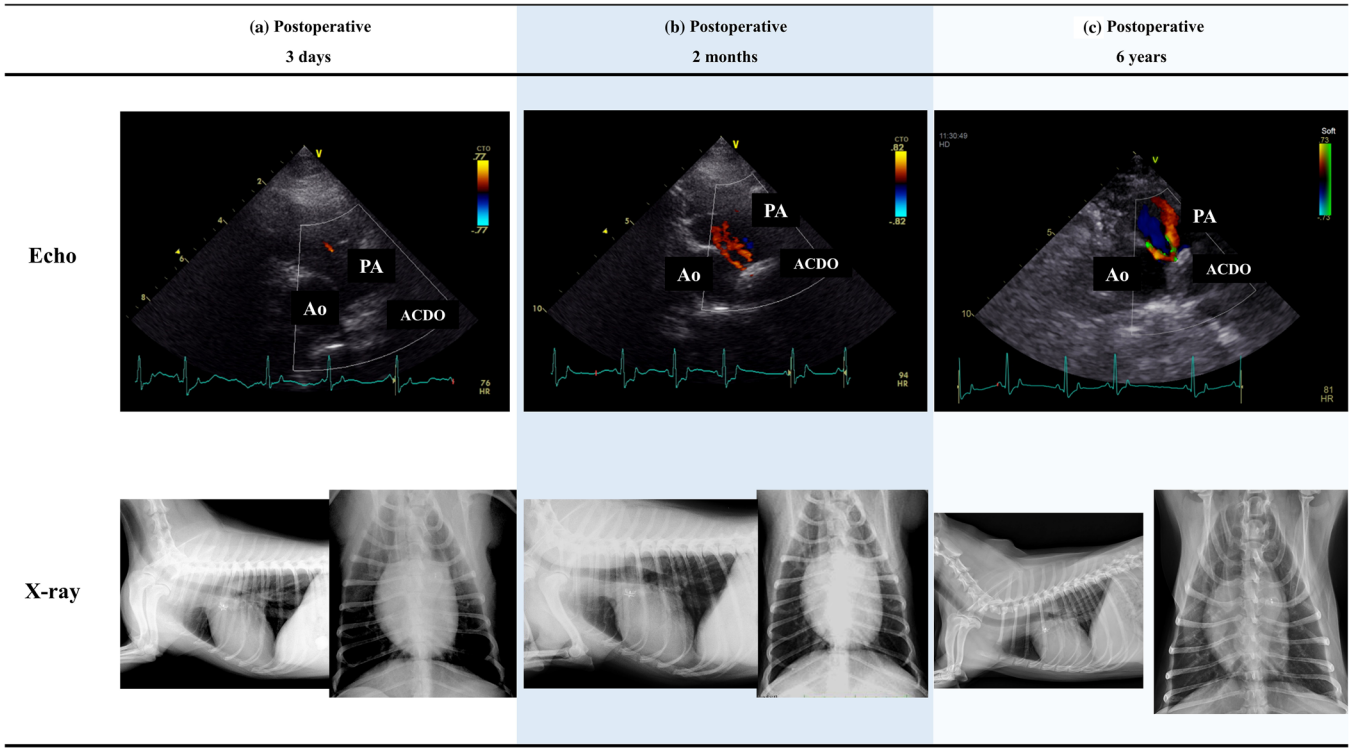

FIGURE 3 Echocardiographic examination after operation. (a) Three days after operation. Complete occlusion was confirmed, as well as 1 month after the operation at which time cardiac dilation was also improved. (b) Two months after operation. Recanalization appeared. (c) Six years after operation. Recanalization deteriorated gradually. The cardiac redilation was not detected. ACDO, Amplatz Canine Duct Occluder; Ao, aorta; PA, pulmonary artery

shunt can lead to congestive heart failure (Van Israel et al., 2003). In dogs, PDA is often treated by interventional procedures, such as coil embolization and ACDO (Ranganathan et al., 2018).

The complications of utilizing an ACDO in dogs are rare but reported to include bacterial endocarditis (Fine & Tobias, 2007), acute embolization (Gordon et al., 2010), and delayed embolization (Carlson et al., 2013). Late complications such as recanalization and development of residual flow are very rare (Broaddus & Tillson, 2010). In dogs, most cases showed no residual ductal flow after ACDO implantation (Nguyenba & Tobias, 2008; Sisson, 2003; Wesselowski et al., 2019), and most of the delayed occlusions were observed in the first 3 months (Nguyenba & Tobias, 2008; Sisson, 2003; Stauthammer et al., 2015). The Amplatz Duct Occluder showed a complete occlusion rate of 100% and no signs of recanalization in long-term follow-up studies performed in human patients with PDA (Koch et al., 2001; Masura et al., 1998). Singh et al. (2012) reported an occlusion of PDA in a dog with vWD and reported that the dog had a lack of thrombosis of the Amplatzer Vascular Plug device. Beijerink et al. (2018) reported a lack of endothelialization of the ACDO associated with bacterial arteritis. Nguyenba and Tobias (2008) reported a residual shunt after an operation using ACDO in a dog. The dog in that report had demonstrated immediate ductal occlusion during the operation; however, Doppler echocardiography revealed trivial recurrent ductal flow 1 day after the operation, and the residual shunt progressed to a moderate degree at 3 months and was unchanged at ≥12 months after the operation. The reason why the recurrent flow appeared and progressed was unknown. Although there were several studies reporting residual PDA shunting, to the best of our knowledge, there have been no reports regarding late recanalization after complete occlusion in dogs with PDA. In the present case, complete occlusion was confirmed, but 2 months after the operation, recanalization appeared and deteriorated gradually.

Von Willebrand disease is a common bleeding disorder. However, we did not suspect vWD before the operation because the general blood examination results showed values within the reference ranges, and the dog had no clinical signs associated with vWD. After placement of an intravascular/intracardiac implant, a series of events take place in which the function of von Willebrand factor is very important (Sigler et al., 2000). First, thrombotic material, consisting of fibrin and blood cells, develops and seals the surface of the implant. This process begins immediately after implantation and usually ends within 1–2 days. Subsequently, fibromuscular cells begin to proliferate, which continues for 2–3 weeks. In the final phase, granulation tissue containing extracellular matrix and fibroblasts and new blood vessels forms (Foth et al., 2009). Von Willebrand factor is a protein that acts as a molecular bridge between platelets and subendothelium as well as a carrier for factor VIII (Denis, 2003; Wagner, 1990), which is important for coagulation. The dog in the present study was discovered to have type 1 vWD in which there is a quantitative deficiency of von Willebrand factor in the circulation. The partial embolization might have caused the temporary complete occlusion; however, late recanalization occurred.

In addition, we considered slippage of the device. Carlson et al. (2013) reported a delayed embolization immediately after unrestricted exercise. In our case, the ACDO was sized appropriately based on published recommendations (minimal ductal diameter/waist diameter of the ACDO: 1.6) (Nguyenba & Tobias, 2007), locomotory activity of the dog was severely restricted for a month, and radiographic and echocardiographic examinations showed no change in the location of ACDO. Furthermore, the residual flow appeared through, rather than around, the ACDO. Therefore, slippage of the device was considered very unlikely.

Despite the development of residual PDA flow, progressive cardiac enlargement was not noted during the follow-up period, suggesting that the degree of residual flow remained mild and clinically inconsequential. This is consistent with an adequate decrease in shunt flow despite recanalization.

In conclusion, we report a case of a dog with late recanalization after ACDO placement that was most likely associated with vWD. Recurrent cardiac enlargement was not detected, consistent with a sustained decrease in shunt flow despite recanalization. Von Willebrand disease in dogs has been reported in more than 50 breeds (Littlewood et al., 1987). Dogs with known heritable risk for both PDA and vWD include Pembroke Welsh Corgi, Doberman Pinscher, and German Shepherd. (Fox et al., 1998; Harvey, 2012). In these breeds, screening for vWD may be considered before PDA occlusion, despite the rare prevalence of this disease.

CONFLICT OF INTEREST

The authors declare no conflict of interest

ETHICS STATEMENT

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. No ethics approval was required as no experimentation was conducted on the treated dog and the consultation was conducted normally.

AUTHOR CONTRIBUTIONS

Conceptualization (lead), original draft preparation (equal), writing-original draft (equal), formal analysis (lead), and writing-review and editing (equal): Masaki Kochi. *Conceptualization (equal), Original Draft Preparation (lead), writing-original draft (lead), formal analysis (supporting), and writing-review and editing (lead)*: Keisuke Sugimoto. *Formal analysis (supporting) and writing-review and editing (supporting)*: Michito Inoue. *Conceptualization (equal), formal analysis (supporting), and writing-review and editing (supporting)*: Takuma Aoki.

PEER REVIEW

The peer review history for this article is available at https://publons.com/publon/10.1002/vms3.634

ORCID

Keisuke Sugimoto https://orcid.org/0000-0002-7565-4960

REFERENCES

Beijerink, N. J., Bergmann, W., & Szatmari, V. (2018). Incomplete endothelialization of an intravascular implant and fatal late-onset bacterial ductal arteritis in a dog with occluded patent ductus arteriosus. *Journal of Veterinary Internal Medicine*, *32*(3), 1155–1159.

Broaddus, K., & Tillson, M. (2010). Patent ductus arteriosus in dogs. *Compendium on Continuing Education for the Practising Veterinary*, *32*(9), E3.

Buchanan, J. W., & Bucheler, J. (1995). Vertebral scale system to measure canine heart size in radiographs. *Journal of the American Veterinary Medical Association*, *206*(2), 194–199.

Carlson, J. A., Achen, S. A., Saunders, A. B., Gordon, S. G., & Miller, M. W. (2013). Delayed embolization of an Amplatz((R)) canine duct occluder in a dog. *Journal of Veterinary Cardiology*, *15*(4), 271–276.

Clyman, R. I. (2006). Mechanisms regulating the ductus arteriosus. *Biology of the Neonate*, *89*(4), 330–335.

Denis, C. V. (2003). Von Willebrand factor in vascular pathophysiology. *Pathologie Biologie*, *51*(7), 395–396.

Fine, D. M., & Tobias, A. H. (2007). Cardiovascular device infections in dogs: Report of 8 cases and review of the literature. *Journal of Veterinary Internal Medicine*, *21*(6), 1265–1271.

Foth, R., Quentin, T., Michel-Behnke, I., Vogt, M., Kriebel, T., Kreischer, A., Ruschewski, W., Paul, T., & Sigler, M. (2009). Immunohistochemical characterization of neotissues and tissue reactions to septal defect-occlusion devices. *Circulation: Cardiovascular Interventions*, *2*(2), 90–96.

Fox, P. R., Sisson, D., & Moïse, N. S. (1998). *Textbook of canine and feline cardiology: principles and clinical practice*. Saunders

Gordon, S. G., Saunders, A. B., Achen, S. E., Roland, R. M., Drourr, L. T., Hariu, C., & Miller, M. W. (2010). Transarterial ductal occlusion using the Amplatz Canine Duct Occluder in 40 dogs. *Journal of Veterinary Cardiology*, *12*(2), 85–92.

Harvey, J. W. (2012). Evaluation of hemostasis: Coagulation and platelet disorders. In J. W. Harvey (Ed.), Veterinary hematology (. 191–233). W.B. Saunders

Koch, A., Hofbeck, M., Buheitel, G., Gerling, S., Rauch, R., & Singer, H. (2001). Advances in interventional occlusion of persistent ductus arteriosus: Comparison of results using different occlusion devices. *Zeitschrift für Kardiologie*, *90*(2), 120–126.

Littlewood, J. D., Herrtage, M. E., Gorman, N. T., & McGlennon, N. J. (1987). Von Willebrand's disease in dogs in the United Kingdom. *Veterinary Record*, *121*(20), 463–468.

Masura, J., Walsh, K. P., Thanopoulous, B., Chan, C., Bass, J., Goussous, Y., Gavora, P., & Hijazi, Z. M. (1998). catheter closure of moderate- to large-sized patent ductus arteriosus using the new Amplatzer Duct Occluder: Immediate and short-term results. *Journal of the American College of Cardiology*, *31*(4), 878–882.

Nguyenba, T. P., & Tobias, A. H. (2007). The Amplatz canine duct occluder: A novel device for patent ductus arteriosus occlusion. *Journal of Veterinary Cardiology*, *9*(2), 109–117.

Nguyenba, T. P., & Tobias, A. H. (2008). Minimally invasive per-catheter patent ductus arteriosus occlusion in dogs using a prototype duct occluder. *Journal of Veterinary Internal Medicine*, *22*(1), 129–134.

Ranganathan, B., LeBlanc, N. L., Scollan, K. F., Townsend, K. L., Agarwal, D., & Milovancev, M. (2018). Comparison of major complication and survival rates between surgical ligation and use of a canine ductal occluder device for treatment of dogs with left-to-right shunting patent ductus arteriosus. *Journal of the American Veterinary Medical Association*, *253*(8), 1046–1052.

Schrope, D. P. (2015). Prevalence of congenital heart disease in 76,301 mixed-breed dogs and 57,025 mixed-breed cats. *Journal of Veterinary Cardiology*, *17*(3), 192–202.

Sigler, M., Handt, S., Seghaye, M. C., von Bernuth, G., & Grabitz, R. G. (2000). Evaluation of in vivo biocompatibility of different devices for interventional closure of the patent ductus arteriosus in an animal model. *Heart*, *83*(5), 570–573.

Singh, M. K., Kittleson, M. D., Kass, P. H., & Griffiths, L. G. (2012). Occlusion devices and approaches in canine patent ductus arteriosus: comparison of outcomes. *Journal of Veterinary Internal Medicine*, *26*(1), 85–92.

Sisson, D. (2003). Use of a self-expanding occluding stent for nonsurgical closure of patent ductus arteriosus in dogs. *Journal of the American Veterinary Medical Association*, *223*(7), 999–1005.

Stauthammer, C. D., Olson, J., Leeder, D., Hohnadel, K., Hanson, M., & Tobias, A. H. (2015). Patent ductus arteriosus occlusion in small dogs utilizing a low profile Amplatz(R) canine duct occluder prototype. *Journal of Veterinary Cardiology*, *17*(3), 203–209.

Van Israel, N., Dukes-McEwan, J., & French, A. T. (2003). Long-term follow-up of dogs with patent ductus arteriosus. *Journal of Small Animal Practice*, *44*(11), 480–490.

Wagner, D. D. (1990). Cell biology of von Willebrand factor. *Annual Review of Cell Biology*, *6*, 6217–246.

Wesselowski, S., Saunders, A. B., & Gordon, S. G. (2019). Anatomy, baseline characteristics, and procedural outcome of patent ductus arteriosus in German Shepherd dogs. *Journal of Veterinary Internal Medicine*, *33*(2), 471–477.

How to cite this article: Kochi, M., Sugimoto, K., Inoue, M., & Aoki, T. (2022). Late recanalization after complete occlusion of patent ductus arteriosus in a Pembroke Welsh Corgi with von Willebrand disease. *Veterinary Medicine and Science*, *8*, 26–30. https://doi.org/10.1002/vms3.634